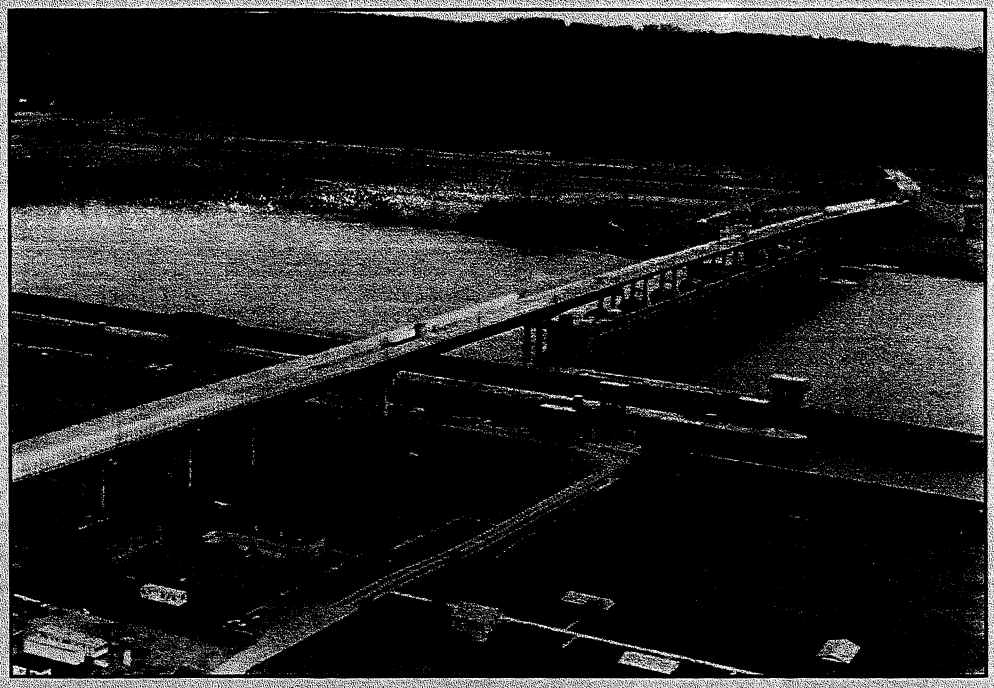
Greenup Locks Improvements

Part B-2. Aquatic & Terrestrial HEP Analysis

Report of Findings
Aquatic and Terrestrial Inventory and
Habitat Evaluation Procedure Analysis

Greenup Locks and Dam

U.S. Army Corps of Engineers



June 1999

BURGESS & NIPLE

REPORT OF FINDINGS
AQUATIC AND TERRESTRIAL INVENTORY
HABITAT EVALUATION PROCEDURE ANALYSIS
GREENUP LOCKS AND DAM

Prepared by
BURGESS & NIPLE, LIMITED
JUNE 1999

ERRATA

- Page vi (Executive Summary), Paragraph 3: The opening sentence should read "*Six* (not seven) *principal habitat types*...."
- Page vii (Executive Summary): The last sentence should read "*A total of 518.258* (not 629.235*) HUs were calculated for terrestrial habitat*..."
- Page 54 (Table 29): The HSI value for Eastern Cottontail should read 0.400 (not 0.833), resulting in an HU value for Eastern Cottontail of 33.200 (not 69.139). The HU value for All Species should read 518.258 (not 629.235).

REPORT OF FINDINGS
GREENUP LOCKS AND DAM IMPROVEMENTS

AQUATIC AND TERRESTRIAL INVENTORY

AND

HABITAT EVALUATION PROCEDURE ANALYSIS

DACW69-97-D-0019 WORK ORDER 0009

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
HUNTINGTON DISTRICT
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JUNE 1999

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EXECUTIVE SUMMARY

Burgess & Niple, Limited (B&N) was retained by the U.S. Army Corps of Engineers (COE), Huntington District to complete terrestrial and aquatic species inventories and baseline Habitat Evaluation Procedure (HEP) Assessments for proposed improvements to the Greenup Locks and Dam on the Ohio River at Greenup, Kentucky. The work was completed under Contract No. DACW69-97-D0019 Work Order 0009. The objective of the terrestrial and aquatic inventories and HEP assessments is to provide data on baseline conditions at the site. Data will be used to assess environmental impacts and mitigation requirements associated with the various alternatives for proposed lock and dam improvements, in accordance with National Environmental Policy Act (NEPA) requirements. The site is located at the Greenup Locks and Dam at River Mile (RM) 341.0 on the Ohio River. The Greenup Locks and Dam are located approximately 4 miles north of Greenup, Kentucky, and approximately 20 miles north of Ashland, Kentucky.

B&N biologists collected all ecological survey data with assistance from Ecological Specialists, Inc. (ESI), of St. Peters, Missouri; BHE Environmental, Inc. (BHE), of Cincinnati, Ohio; and ENSR of Lafayette, Louisiana. Unionid collections were performed by biologists from ESI. The Indiana Bat (*Myotis sodalis*) survey was performed by BHE of Cincinnati, Ohio. ENSR assisted in the terrestrial survey and HEP Assessments.

Seven principal habitat types were identified in the terrestrial and aquatic study area including Open Field with an areal extent of 83 acres, Riparian Forest with an areal extent of 47 acres, River Bank Habitat with an areal extent of 9 acres, Upstream Riverine with an areal extend of 40 acres, Downstream Riverine with areal extent of 216 acres, and Backwater Habitat with areal extent of 23 acres. A total of 39 bird, 12 mammal, 2 reptile/amphibian, 68 plant, 29 fish, 24 unionid mussel species, and 20 macroinvertebrate taxa were collected during the survey. The mist net survey did not confirm the presence of federally endangered Indiana Bat. Habitat potential was assessed as low to moderate, with scattered large cottonwoods in the mature woods, located outside the study area, providing the most likely potential roosting habitat. The mussel portion of the aquatic inventory identified the federally endangered mussel, ring pink. The species was collected as a subfossil shell which is characterized as being dead for 10 or more years.

A modified/abbreviated HEP analysis was conducted on the study area to provide repeatable, quantified indices that can be used to evaluate the quality of the habitat for wildlife and a basis for mitigation needs. The Pennsylvania Modified HEP (PAM HEP) methodology formed the basis of the subject HEP analysis; however, the process was abbreviated in that not all PAM HEP forms were prepared, and in that the procedures were restricted to address only baseline existing conditions. A Habitat Unit (HU) is defined as the equivalent of 1.0 acres of habitat with a Habitat Suitability Index (HSI) value of 1.0 (optimal habitat). HUs are calculated for compartments as the product of the HSI in the compartment (HUs = HSI x acres). Because an HU is an equivalent measure, 1.0 HU may be represented by 1.0 acres of habitat with an HSI of 1.0, 2.0 acres of habitat with an HSI of 0.5, or any other combination with a product of 1.0. A total of 629.235 HUs were calculated for terrestrial habitat and a total of 524.925 HUs were determined for aquatic habitat in the study area.

1.0 INTRODUCTION

1.1 Project Background

B&N was retained by the U.S. COE, Huntington District to complete terrestrial and aquatic species inventories and baseline HEP Assessments for proposed improvements to the Greenup Locks and Dam on the Ohio River at Greenup, Kentucky. The work was completed under Contract No. DACW69-97-D-0019 Work Order 0009.

The project is part of the Ohio River Main Stem Study, a comprehensive evaluation of maintenance, rehabilitation, construction, and habitat restoration needs for the Ohio River navigation infrastructure system. Preliminary traffic congestion and economic analysis data has indicated the need for an Interim Ohio River Main Stem Study and Report to address short-term needs at the Greenup Locks and Dam and John T. Myers Locks and Dam in Mount Vernon, Indiana.

1.2 Project Objectives

The objective of the terrestrial and aquatic inventories and HEP assessments is to provide data on baseline conditions at the site. Data will be used to assess environmental impacts and mitigation requirements associated with the various alternatives for proposed lock and dam improvements, in accordance with NEPA requirements.

1.3 Location

The site is located at the Greenup Locks and Dam at RM 341.0 on the Ohio River. The Greenup Locks and Dam are located approximately 4 miles north of Greenup, Kentucky, and approximately 20 miles north of Ashland, Kentucky. A site location map is provided as Figure 1.

1.4 Definition of Study Area

The terrestrial inventory study area encompassed approximately 166 acres of Corps lands on the west bank (Kentucky side) of the Ohio River at the Greenup Locks and Dam, Kentucky. In addition, an approximately 500-foot corridor of adjacent land between RM 340.5 and RM 343.0 was also inventoried.

The aquatic inventory study area encompassed 2.5 miles in the Ohio River main stem, extending from RM 340.5 just south of the Greenup Locks and Dam north to RM 343.0.

Study area limits are shown on Figure 1.

1.5 Site History and Facilities

The Greenup locks were constructed in 1954 and placed into full operation in 1959. Construction of the dam began in 1958, and the dam pool was raised to full height in 1962. There are currently two parallel locks. The main lock chamber is 110 feet wide by 1,200 feet long, and the auxiliary lock chamber is 110 feet wide by 600 feet long. The dam is a nonnavigable, high-lift, gated dam, top length 1,287 feet, including 245-foot fixed weir with 223-foot open crest. State Route 10 crosses the river above the dam on the Jesse Stuart Highway Bridge. A 70,000-kilowatt hydroelectric plant located at the dam is operated by the City of Vanceburg, Kentucky. A recreation area is also located at the locks and dam. A natural gas transmission pipeline operated by Tennessee Gas Company runs through a portion of the study area, culminating in an aerial pipeline river crossing approximately 1/2 mile north of the locks and dam.

2.0 METHODS

This section describes methodologies used to characterize terrestrial and aquatic ecology and the potential for occurrence of threatened and endangered (T&E) species in the study area. Results are presented in the Literature Review and Results sections following.

Available background data was reviewed prior to initiation of fieldwork. Sources of background data reviewed include U.S. Geological Survey (USGS) topographic maps, National Wetlands Inventory (NWI) maps, natural heritage data available from the Ohio Department of Natural Resources (ODNR) and Kentucky State Nature Preserves Commission (KSNPC), available previous environmental assessment reports, and available background information regarding operation of the locks and dam.

B&N biologists collected all ecological survey data with assistance from ESI of St. Peters, Missouri; BHE of Cincinnati, Ohio; and ENSR of Lafayette, Louisiana. Unionid collections were performed by biologists from ESI. The Indiana Bat (*Myotis sodalis*) survey was performed by BHE of Cincinnati, Ohio. ENSR assisted in the terrestrial survey and HEP Assessments.

A Kentucky Scientific Wildlife Collecting Permit was issued for the work by The Kentucky Department of Fish & Wildlife Resources May 6, 1999. A copy of the permit is included in Appendix A.

2.1 Terrestrial Ecology

The terrestrial survey included an inventory and a description of flora and fauna in all habitat types.

2.1.1 Flora

Identification of the terrestrial communities and their characteristics is necessary to determine construction impacts to the terrestrial ecology of the study area. Terrestrial communities were investigated May 10 through May 14, 1999. B&N reviewed previous documentation of vegetation within the study area prior to initiating fieldwork and delineated vegetative cover types (habitat types), including herbaceous vegetative land, on aerial photographs. B&N scientists then field-verified the aerial photograph interpretation. Dominant plant species and vegetation size and density were recorded for each cover type. Specifically, one 30-foot radius sample point for each vegetative cover type was chosen for

recording plant species and vegetation size and density. Sample points were chosen as being representative of the habitat. Each sample point was searched until no additional species were discovered. Vascular plant species were identified using appropriate botanical works of the region, but nomenclature conforms to Kartesz (1994a, b) and Reed (1988). Species abundance was visually estimated. Habitats were then classified based on *Plant Communities of Ohio: A Preliminary Classification and Description* (Anderson, 1981) and *Classification of Wetlands and Deepwater Habits of the United States* (Cowardin et al., 1979).

2.1.2 **Fauna**

Qualitative faunal surveys were completed concurrently with the vegetation survey using direct observation when possible, including mist net surveys and live trapping. In cases where direct observation was not possible, other indicators were used, i.e., vocalizations, skeletons, nests and burrows, scat, and tracks. Nomenclature for herpetofauna and mammals was provided by Banks et al. (1987). Avifauna nomenclature conforms to the American Ornithologists Union (1983, 1985, 1987, and 1989).

Mist net sites were selected to be representative of each habitat type and placed in likely flyway corridors for bird species. Nets were 8.5 feet high by 40 feet wide and constructed of black nylon mesh with 1.2-inch (30-millimeter) openings. A total of six nets were deployed in the three principal habitat types: open field, riparian forest, and river bank habitat. Nets were deployed from daylight to dusk for a period of 2 days and rolled up at night. Nets were checked frequently during the course of the day and captured individuals were identified and released.

Live traps were used to sample small mammal populations difficult to observe directly or through tracks and other sign. Live traps were 2-inch by 2-inch by 6.5-inch folding aluminum traps baited with rolled oats. A total of 300 traps were deployed in four principal habitat types over a period of 3 days and 2 nights. Traps were placed along transects in groups of five spaced approximately 60 feet apart. Traps were checked frequently during the day. Traps were left overnight and checked the following morning at daylight. Captured individuals were identified and released.

2.2 Aquatic Ecology

An aquatic inventory to document baseline conditions within the Ohio River in the vicinity of the Greenup Locks and Dam between RM 340.5 and RM 343 was conducted by B&N in conjunction with ESI of St. Peters, Missouri, on May 17, 18, 19, and 20, 1999. The aquatic inventory was conducted along the west shore of the Ohio River in Greenup County, Kentucky. The results of the qualitative survey were used to compile aquatic species inventory lists for vertebrates (fish), macroinvertebrates, and unionid mussels. Habitat and water quality data between RMs 340.5 and RM 343 were also collected during the survey.

Both field and laboratory methodologies used during performance of the aquatic inventory for Greenup Locks and Dam were consistent with the Ohio Environmental Protection Agency's (EPA's) *Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities* (Ohio EPA, 1989).

2.2.1 Vertebrates

The aquatic vertebrate inventory was completed using boat-mounted electrofishing equipment and a circular electrode array. The boat was equipped with a generator, Coffelt electrofishing unit, and a positive pressure cut-off foot pedal switch. Electrofishing was conducted in an upstream to downstream direction using a zigzag pattern along the shoreline. The entire area from RM 340.5 to RM 343 was sampled on both Tuesday, May 18, and Wednesday, May 19, 1999, for a total of two electrofishing passes over the study area. Habitat areas were sampled in 100-meter intervals for the upstream portion and 200-meter intervals for the downstream portion. Fish were netted using dip nets and immediately placed in a live well for identification at the end of each electrofishing zone. All vertebrate individuals were identified at the site and returned to the Ohio River following identification. Voucher samples of species not able to be identified in the field were preserved in 10-percent formalin and returned to the lab for identification. Voucher photographs were taken in the field where possible for documentation of species collected during the inventory. Taxonomic identification and distribution information followed Trautman (1981) and Page and Burr (1991).

2.2.2 Macroinvertebrates

Macroinvertebrate sampling was conducted on Thursday, May 20, 1999, using a manual Ponar Grab to collect bottom samples within different habitat areas. Each grab sample was transferred to a tub which was poured through a wash bucket with a No. 30-mesh (600-micrometer [μm]) stainless steel wire cloth to retain the sample. All material collected from a grab was preserved in 10-percent formalin and transported back to the lab for processing and identification. In the lab, all samples were rinsed with water and passed through No. 40 (420-μm) and No. 30 (600-μm) Standard Testing Sieves. Material collected on the No. 40 screen was transferred to sample jars for later identification. Material from the No. 30 screen was observed at 3X power using a standard dissecting microscope to remove any remaining macroinvertebrates. All macroinvertebrates collected during the aquatic inventory were identified to the most specific taxonomic level possible considering the number of specimens collected and the condition of the specimens. The samples were vouchered in 70-percent isopropanol and later identified to species using taxonomic references that included Merritt and Cummins (1978), Pennak (1953), and Burch (1982). Voucher specimens of macroinvertebrates collected during the aquatic inventory are maintained at B&N.

2.2.3 Unionids

For purposes of the mussel (unionid) inventory and assessment of aquatic habitat areas, the study area was divided up into transects. Semiquantitative sampling was performed along transects created perpendicular to the west bank of the Ohio River. The area from RM 340.5 north to the lock and dam was divided into five transects identified as T1 through T5 which were spaced 100 meters apart. The area from the lock and dam north to RM 343 was divided into 13 more transects marked as T6 through T18 which were spaced 200 meters apart along the shoreline. These transects served as the basis for dividing up collection areas for unionids. Additional qualitative sampling was conducted in areas of unionid concentrations. Detailed information on the methodologies used to complete the unionid inventory is included in the report prepared by ESI. (Appendix B).

2.2.4 Water Quality

Indicators of water quality within different habitat types were measured in the field during the aquatic inventory. Parameters measured during the study included turbidity (secchi depth), dissolved oxygen (DO), current velocity, temperature, pH, and conductivity. Measurements were taken along the shoreline, and on average, approximately 18 meters from the bank. Measurements were taken just below[15]

the water surface and on the bottom within each zone. Final measurements within different habitat areas were averaged to give an indication of overall water quality. Data on water depth and bottom substrates was also collected within each habitat type encountered.

2.3 Threatened and Endangered Species

Several investigations were undertaken to discern the absence, presence, or probable occurrence of T&E plant and animal species in the study area. These studies were conducted in the following order and rationale.

First, existing background ecological information was reviewed for any indication of the past, present, or probable occurrence of protected species, or their preferred habitats, in or near the study area. Secondly, information requests were forwarded to the state and federal agencies responsible for the protection and maintenance and existence of such species, requesting information they maintain regarding the existence of these species in the study area. With this information, B&N scientists visited the study area to investigate the suitability of the existing on-site habitats for the state- and federal-listed species. A habitat map was produced using AutoCAD Version 12, and habitats were quantified. Biological surveys were conducted for plants, mammals, avifauna, herpetofauna, fish, macroinvertebrates, and unionid mussels. The potential for occurrence of T&E species was estimated based on the occurrence of preferred habitat because T&E species are, by definition, difficult to locate. Based on a request by U.S. Fish and Wildlife Service (F&WS) potential Indiana Bat habitat located on the site surveyed by BHE.A copy of the report outlining details of the methodology used by BHE in the survey is included in Appendix C,

Agency sources contacted for information included ODNR, Division of Natural Areas and Preserves (DNAP) and KSNPC. Data on T&E species were also obtained from the F&WS. These agencies list T&E species status in the United States, Ohio, and Kentucky and include any state-designated special interest species.

3.0 LITERATURE REVIEW

This section contains the findings of the literature review and agency consultation that were performed prior to the site investigation.

3.1 Topography and Land Use

The study area is part of the Mountains and Eastern Coalfields physiographic region of the unglaciated Allegheny Plateau. The topography is generally level or gently rolling floodplain and terraces, with the exception of riverbank and stream ravine areas where topography is steep. Current land uses in the study area include agricultural land, paved and mowed areas and structures associated with the locks and dam, recreational areas, wooded areas associated primarily with streams, and cleared and mowed areas associated with a natural gas transmission pipeline.

3.2 Geology

The geology consists of Pennsylvanian and Mississippian Systems. The Pottsville and Allegheny Groups represent the Pennsylvanian System, and the Waverly Group represents the Mississippian System.

The bedrock consists of interbedded shale, siltstone, and sandstone with a few limestone layers in the Upper Pennsylvanian and Upper Mississippian. The most extensive bedrock in the area is the Breathitt Formation (Hail et al., 1979).

3.3 Soils

Most of the soils formed in material weathered from acid shale, sandstone, and siltstone, and minor amounts formed from calcareous shales. The soils for the study areas consist of the Elk-Huntington-Otwell Association. This association consists of deep, well-drained and moderately well-drained, nearly level soils on terraces and floodplains.

Huntington series soils occupy the river floodplain in the study area and are deep, well-drained alluvial soils formed from mixed materials of shale, sandstone, and limestone origin. Permeability is moderate. The surface layer is very dark grayish brown silt loam about 11 inches thick. The subsoil from

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11 to 64 inches is dark grayish brown and dark brown silt loam. Bedrock is found at depths of 40 to 84 inches or greater.

Elk series soils are a deep, well-drained soils found on stream terraces. The surface layer is dark brown silt loam about 9 inches thick. The subsoil, about 36 inches thick, is dark brown or brown silt loam or light silty clay loam. The substratum to a depth of 73 inches is dark yellowish brown or dark brown stratified sandy loam and loam. Permeability is moderate.

Otwell series soils are a deep, moderately well-drained, nearly level and gently sloping soils that have a fragipan. Otwell soils formed in alluvium deposited by the Ohio River. These nearly level soils are found on low ridges that are roughly parallel to the Ohio River. The surface layer is dark brown silt loam about 7 inches thick. The upper part of the subsoil is brown and yellowish-brown, friable silt loam that extends to a depth of about 26 inches. The lower part of the subsoil is a firm, brittle, and compact fragipan with redox featured silt loam that extends to a depth of about 40 inches. The fragipan rests on a firm substratum of brown, silt loam with redox features that extends to a depth of 60 inches or more. Permeability is moderate above the fragipan and is slow in the pan (Hail et al., 1979).

3.4 Present Land Use Practices

The study area lies within the Western Allegheny Plateau ecoregion as described by Omerink and Gallant (1988). An ecoregion is an area that contains relatively homogeneous land use, potential natural vegetation, land surface form, and soils (Omerink, 1987). The Western Allegheny Plateau ecoregion land use is limited by poor soils, steep topography, and high erosion hazard. Thus, most of the area is forested, and timber harvest is important. A large portion has been strip-mined for coal. Less than 20 percent is cropland, which occurs in valley floors usually in alfalfa and small grains for beef and dairy cattle. Fruit and vegetables are found on a local scale. Urban growth continually infringes on forested areas.

3.5 Terrestrial Resources

3.5.1 Historical Terrestrial Resources

Prior to development, the study area was completely forested. The Unglaciated Allegheny Plateau is within the limits of the historical Mixed Mesophytic Forest community. Extensive tracts of an elm-ash-maple-type (American elm [*Ulmus americana*], black ash [*Fraxinus nigra*], white ash [*Fraxinus*[18]

americana], and red maple [*Acer rubrum*]) occurred in depressions and bottomland portions of the study area (Braun, 1947).

European settlers exacted great changes on the landscape in the mid-to-late 1800s. These changes continued into the 1940s when the study area resembled existing vegetative conditions (Lamb, 1979). Human activities in the study area have altered the natural environment primarily through agriculture and urbanization. Approximately 90 percent of the area has been modified to forestry, agriculture, lawns, buildings, and other development. The remaining forest areas are dissected and located on gently sloping to very steep areas found along the river corridors. These forest areas provide riparian habitat; however, because of human development and pollution, they do not currently provide the high quality habitats of the past.

3.5.2 Recent Terrestrial Survey Results

Due to recent changes in the study area caused by agricultural activities, only the most recent studies regarding terrestrial ecology are applicable. The most recent study is an unpublished report prepared by COE biologists for the study area in 1998. The study included an inventory of terrestrial species for the study area. A complete copy of the report is provided in Appendix D.

3.6 Aquatic Resources

The Aquatic Resources section describes the historical and current conditions of the only major aquatic resource in the study area, the Ohio River.

3.6.1 Historical Aquatic Resources

Prior to the 1750s, the Ohio River was dominated by fish, molluscan, and invertebrate communities that preferred clean, clear water and silt-free, course substrates (Trautman, 1981). The abundance of forests, wetlands, and natural vegetation that maintained these high-quality river and stream conditions slowly gave way to agricultural interests as farming practices became more widespread and mechanized. Farming interests cleared forests, drained fields and wetlands, dredged, cleared, and channelized streams in order to increase the arable acreage of the land. The practices had significant impact on the hydrologic conditions of the state, resulting in a lower water table, lower stream flows, and an increase in erosion of sediments from farmed lands. The subsequent increase in erosion caused 19

elevated levels of suspended solids in streams and the silting over of the clay-free substrates. As a result of these perturbations, the fish and molluscan communities have since been modified from communities requiring clean water and substrates to communities tolerant of turbid waters and fine substrates. The increase in the human population and the industrialization of the early 1900s increased the organic and inorganic pollution inputs to the streams and rivers in the study area (Trautman, 1981).

The construction and subsequent upgrade of wastewater treatment plants to meet Clean Water Act (CWA) regulations and a decrease in industrial effluent per the National Pollutant Discharge Elimination System has begun, and continues, to allow improvement of water quality and habitat quality of the Ohio River (Trautman, 1981).

3.6.2 Recent Aquatic Survey Results

Many of the streams within the Western Allegheny Plateau ecoregion are channelized, but the higher quality streams still have some wooded riparian vegetation. The Ohio River is classified as Warmwater Habitat by the Ohio EPA (1993). The warmwater habitat designation is applied to waters capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization comparable to the 25th percentile of the identified reference sites within their respective ecoregion.

Currently, the Ohio River Valley Water Sanitation Commission (ORSANCO) is conducting ongoing aquatic sampling on the Ohio River, including the study area. The most recent information provided by ORSANCO is included in Appendix E.

3.7 Threatened and Endangered Species

Under Section 7 consultation, the U.S. F&WS provided a list of federally listed T&E species found in the states of Ohio and Kentucky. The list shows counties of current, recent (25 years), and possible distributions. The study area is within the range of the following species; however, there has been no confirmation of their presence within the study area. In addition, there is no documented occurrence of critical habitat within the study area for any federally listed T&E species.

- The Indiana Bat is a state and federal endangered species that has a possible distribution in Greenup County. Caves and caverns are the preferred winter habitat and are utilized for hibernating (Gottschang, 1981). Dead trees and snags along riparian corridors–especially those with exfoliating bark (e.g., shagbark hickory)–may be used by the Indiana bat as maternity roost areas. Stream corridors and nearby woodlots may be used as forage areas.

- Federally endangered mussel species possibly occurring in the vicinity of Greenup Locks and Dam and found recently in upper Ohio River as documented by U.S. F&WS are as follows:

  - Fanshell (*Cyprogenia stegaria*)
  - Pink mucket (*Lampsilis abrupta*)
  - Tubercled blossom (*Epioblasma t. torulosa*)
  - Ring pink (*Obovaria retusa*)
  - White wartyback (*Plethobasus cicatricosus*)
  - Orange-foot pimpleback (*Plethobasus cooperianus*)
  - Clubshell (*Pleurobema clava*)
  - Rough pigtoe (*Pleurobema plenum*)

  Because mussels are suspension feeders, their preferred habitat includes areas with relatively good water quality including significant current velocities and low siltation. In riverine systems, the best mussel habitat can usually be found in areas of heterogeneous substrates consisting of less coarse sediments near river banks as opposed to channel areas. Specifically, unionid beds are most typically located in areas characterized by a mixture of stable sand, gravel, and cobble substrates. Depositional areas are usually lacking in any significant mussel communities based on the constantly shifting and changing nature of these zones.

The ODNR/DNAP and KSNPC were contacted to review their Natural Heritage maps and files for reported occurrences of rare, special interest, threatened, and endangered species in the vicinity of the study area.

ODNR/DNAP reported the following plant species occurrences in the vicinity of the study area (Table 1). Both occurrences are approximately at the foot of the aerial gas pipeline crossing on the Ohio side. 21

Table 1. Ohio Heritage Program, terrestrial species with reported occurrences.

Scientific Name	Common Name	Status
Paspalum fliuitans	riverbank paspalum	Potentially threatened
Descurainia pinnata	tansy mustard	Threatened

KSNPC reported the following plant species occurrences in the vicinity of the study area (Table 2). The single report was from the junction of the C&O Railroad track and the natural gas pipeline near Gray's Branch, just west of the study area boundary.

Table 2. Kentucky Heritage Program, terrestrial species with reported occurrences.

Scientific Name	Common Name	Status
Sida hermaphrodita	Virginia mallow	Special concern

None of the above-referenced species were encountered during the terrestrial inventory conducted by B&N in the vicinity of Greenup Locks and Dam.

The ODNR/DNAP was contacted to review their Natural Heritage maps and files for the vicinity of Greenup Locks and Dam located on the Wheelersburg USGS 7.5-minute quadrangle for Scioto County, Ohio. Records from ODNR/DNAP for aquatic species with a special status in Ohio occurring in the vicinity of the site are shown in Table 3.

Table 3. Ohio Heritage Program, aquatic species with reported occurrences.

Scientific Name	Common Name	Status
Lepisosteus platostomus	Shortnose Gar	Ohio Endangered
Esox masquinongy	Muskellunge	Ohio Special Interest
Ichthyomyzon unicuspis	Silver Lamprey	Ohio Threatened
Hiodon alosoides	Goldeye	Ohio Endangered
Moxostoma carinatum	River Redhorse	Ohio Special Interest
Hiodon tergisus	Mooneye	Ohio Special Interest

None of the above-referenced species were encountered during the aquatic inventory conducted by B&N in the vicinity of Greenup Locks and Dam.

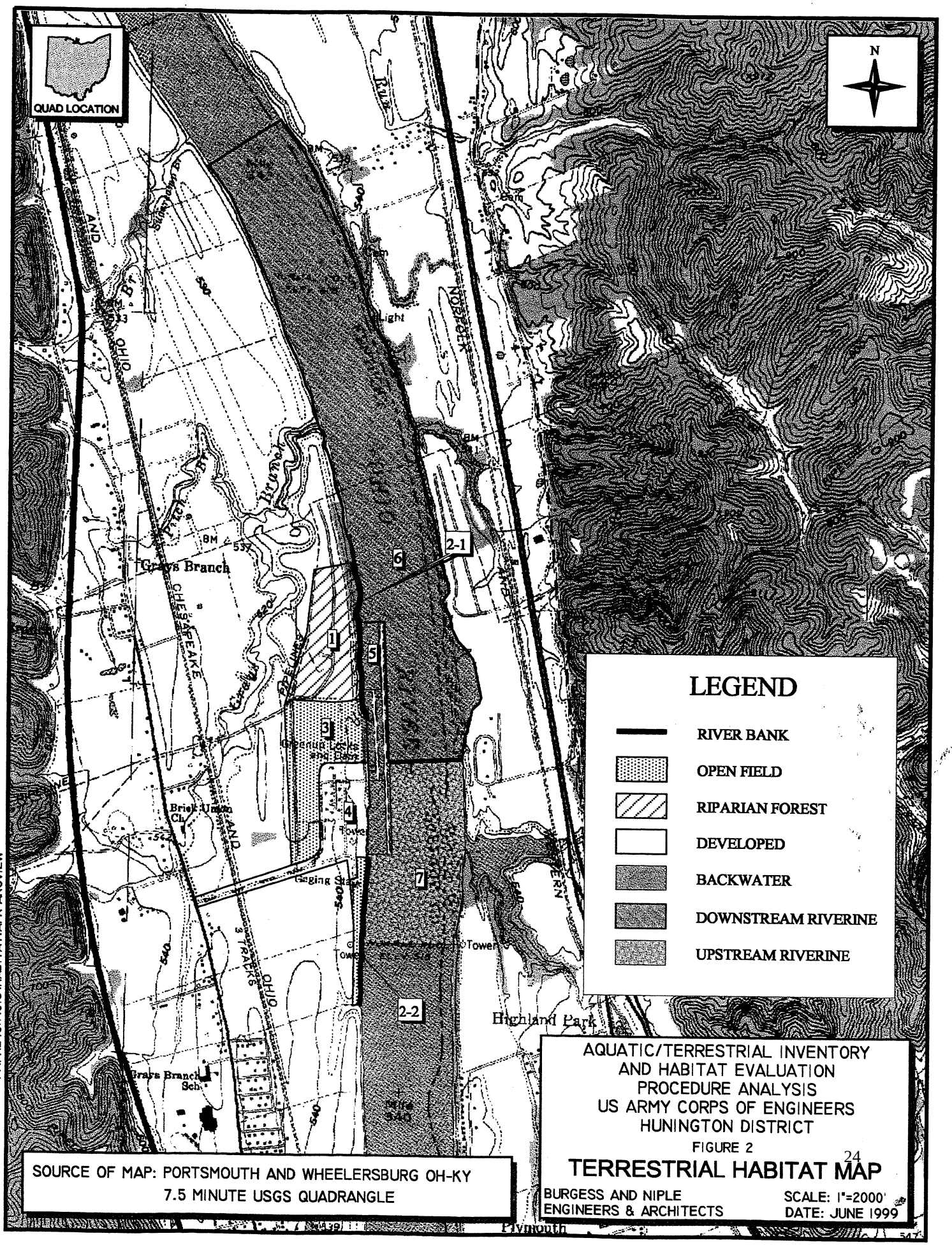
The KSNPC was also contacted for any information on potential threatened or endangered species which may have been reported for the study area. The Natural Heritage Program Database was reviewed to determine if any of the endangered, threatened, or special-concern plants and animals or 22

exemplary natural communities monitored by KSNPC had a record of occurrence within the vicinity of Greenup Locks and Dam. The agency reported three occurrences of aquatic animals within the specified area as shown in Table 4.

Table 4. Kentucky Heritage Program, aquatic species with reported occurrences.

Scientific Name	Common Name	Status
Obovaria retusa	Ring Pink	Kentucky Endangered and Federally Endangered
Pleurobema pyramidatum	Pyramid Pigtoe	Kentucky Endangered
Percopsis omiscomaycus	Trout-Perch	Kentucky Special Concern

The ring pink and pyramid pigtoe were last observed or collected from the vicinity of the site in 1929. Both specimens were found in the Ohio River at the mouth of Ginat Creek upstream of the study area. The trout-perch was last observed in 1905 in the Greenup Pool area of the Ohio River.



SOURCE OF MAP: PORTSMOUTH AND WHEELERSBURG OH-KY
7.5 MINUTE USGS QUADRANGLE

AQUATIC/TERRESTRIAL INVENTORY
AND HABITAT EVALUATION
PROCEDURE ANALYSIS
US ARMY CORPS OF ENGINEERS
HUNINGTON DISTRICT

FIGURE 2

TERRESTRIAL HABITAT MAP

BURGESS AND NIPLE
ENGINEERS & ARCHITECTS

SCALE: 1"=2000'
DATE: JUNE 1999

P:\PR2461\GIS\HABITAT.APR ARCVIEW

4.0 RESULTS

The Results section discusses the findings of the terrestrial and aquatic field surveys. Lists of terrestrial and aquatic species and their habitats are located in Tables 5 through 9. Water quality results obtained during the aquatic survey are summarized in Table 10. Photographs of the referenced habitats are provided in Appendix F.

4.1 Terrestrial Ecology

Four principal habitat types were identified in the study area: open field, riparian forest, and river bank habitat. Mowed, paved areas, and agricultural fields were not considered as viable habitat types and were excluded from the survey. A map showing the distribution of the four principal terrestrial habitat types is provided on Figure 2. Habitat types are described below.

Open Field – Open field areas occurred in the vicinity of the locks and dam and gas transmission pipeline easement. These areas generally lack woody vegetation and are dominated by unmowed pasture grasses and meadow species. Total acreage in this habitat type within the study area is approximately 83 acres.

Riparian Forest – This habitat type consists of approximately 47 acres located between the maintained areas around the locks and dam and the aerial gas transmission pipeline crossing to the north. The tree canopy was relatively open (40-percent canopy closure), and the area is dissected by several dirt roads and trails. Understory growth is generally dense throughout. Average canopy height is approximately 30 feet. Estimated age of canopy trees was 15 to 20 years. Dominant canopy species include cottonwood (*Populus deltoides*), box elder (*Acer negundo*), silver maple (*Acer saccharinum*), and sycamore (*Platanus occidentalis*). Black locust, (*Robinia pseudoacacia*), black cherry (*Prunus serotina*), American elm (*Ulmus americana*), and box elder are dominant tree species in the understory.

River Bank – This habitat type occupies virtually the entire length of the river shoreline within the study area, and is characterized by sparse vegetation and intermittently exposed sand beaches and mud flats. At the time of the inventory, the area was colonized primarily by willows (*Salix* spp.) and pioneer herbaceous species, including field horsetail (*Equisetum arvense*), lamb's quarters (*Chenopodium album*), beggar's tick (*Bidens frondosa*), swamp smartweed (*Polygonum coccineum*) and cottonwood (*Populus deltoides*) seedlings. Mammal and bird tracks and other signs were prevalent in this area indicating its importance as a pivotal corridor used by many animal species. Total estimated acreage in this type of habitat is approximately 9 acres.

4.1.1 Terrestrial Inventory Species Lists

Tables 5 and 6 below list the terrestrial animal and plant species observed within the study area. Species are listed alphabetically by Scientific name.

Table 5. Terrestrial animal species, May 1999.

BIRDS		
Scientific Name	**Common Name**	**Habitat**
Agelaius phoeniceus	Redwing Blackbird	Open Field
Anas platyrhynchos	Mallard Duck	Riparian Forest
Archilochus colubris	Ruby-Throated Hummingbird	Riparian Forest/River Bank
Bombycilla cedrorum	Cedar Waxwing	Riparian Forest
Branta canadensis	Canada Goose	River Bank/open Field
Buteo jamaicensis	Red-Tailed Hawk	Open Field
Butorides striatus	Green Heron	Riparian Forest
Cardinalis cardinalis	Cardinal	Riparian Forest
Cathartes aura	Turkey Buzzard	Open Field
Charadrius vociferous	Killdeer	Open Field
Colaptes auratus	Yellow-Shafted Flicker	Open Field
Corvus brachyrhynchos	Common Crow	River Bank
Cyanocitta cristata	Blue Jay	Riparian Forest
Dryocopus pileatus	Pileated Woodpecker	Riparian Forest
Dumatella carolinensis	Catbird	Riparian Forest
Fulica americana	American Coot	River Bank
Geothlypis trichas	Common Yellowthroat	Riparian Forest
Hirundo rustica	Barn Swallow	Open Field
Hylocichla mustelina	Wood Thrush	Riparian Forest
Icterus galbula	Baltimore Oriole	Open Field
Parus bicolor	Tufted Titmouse	Riparian Forest
Passerina cyanea	Indigo Bunting	Riparian Forest
Phalacrocorax auritus	Double Crested Cormorant	River Bank

BIRDS (Continued)		
Scientific Name	**Common Name**	**Habitat**
Picoides villosus	Hairy Woodpecker	Riparian Forest
Pipilo erythrophthalmus	Rufous-Sided Towhee	Riparian Forest
Progne subis	Purple Martin	Open Field
Quiscalus quiscula	Common Grackle	Riparian Forest
Setophaga ruticilla	Redstart	Riparian Forest
Sialia sialia	Eastern Bluebird	Open Field
Sturnella magna	Eastern Meadow Lark	Open Field
Sturnus vulgaris	Starling	Open Field
Thryothorus ludovicianus	Carolina Wren	Riparian Forest
Toxostoma rufum	Brown Thrasher	Woods
Turdus migratorius	American Robin	Riparian Forest
Vireo olivaceus	Red-Eyed Vireo	Riparian Forest
Zenaida macroura	Mourning Dove	Open Field
Total No. Bird Species = 39		

MAMMALS		
Scientific Name	**Common Name**	**Habitat**
Blarina brevicauda	short-tailed shrew	Open Field
Castor canadensis	beaver	River Bank
Didelphis virginiana	possum	Riparian Forest
Eptesicus fuscus	big brown bat	Riparian Forest
Marmota monax	woodchuck	Open Field
Microtus pennsylvanicus	meadow vole	Open Field
Odocoileus virginianus	whitetail deer	Riparian Forest
Peromyscus maniculatus	deer mouse	Riparian Forest
Procyon lotor	raccoon	Riparian Forest/River Bank
Reithrodontomys humulis	Eastern harvest mouse	Open Field
Tamias striatus	Eastern chipmunk	Riparian Forest
Vulpes vulpes	red fox	River Bank
Total No. Mammal Species = 12		

REPTILES/AMPHIBIANS		
Scientific Name	**Common Name**	**Habitat**
Chrysemys picta picta	Eastern painted turtle	River Bank
Terrapene carolina carolina	Eastern box turtle	Riparian Forest
Total No. Reptile/Amphibian Spp = 2		

Table 6. Terrestrial plant species, May 1999.

PLANTS		
Scientific Name	**Common Name**	**Habitat**
Acer negundo	box elder	Riparian Forest
Acer saccharinum	silver maple	Riparian Forest
Actinomerus alternifolia	wingstem	Riparian Forest
Agrostis alba	redtop grass	Open Field
Allium canadense	wild garlic	Riparian Forest
Amorpha fruticosa	false indigo	Open Field
Arctium minus	burdock	Open Field
Asclepias syriaca	milkweed	Open Field
Barbarea vulgaris	yellow rocket	Open Field
Bidens frondosa	beggars tick	Open Field/River Bank
Boehmeria cylindrica	false nettle	Riparian Forest
Bromus tectorum	brome grass	Open Field
Campsis radicans	trumpet creeper	Riparian Forest
Capsella bursa-pastoris	shepherds purse	Open Field
Carex intumescens	bladder sedge	Riparian Forest
Carya cordiformis	bitternut hickory	Riparian Forest
Carya lacinosa	shellbark hickory	Riparian Forest
Chenopodium album	lambs quarters	River Bank
Convolvulus arvensis	field bindweed	Open Field
Dactylis glomerata	orchard grass	Open Field
Equisetum arvense	field horsetail	River Bank
Erigeron annuus	daisy fleabane	Open Field
Fraxinus pennsylvanica	green ash	Riparian Forest
Galium aparine	cleavers	Riparian Forest
Geranium pusillum	small-flowered cranesbill	Open Field
Glechoma herderacea	ground ivy	Riparian Forest
Impatiens capensis	jewelweed	Riparian Forest
Juglans nigra	black walnut	Riparian Forest
Lamium pupurea	purple deadnettle	Open Field
Lolium multiflorum	Italian ryegrass	Open Field
Lonicera japonica	Japanese honeysuckle	Riparian Forest
Medicago lupilina	black medic	Open Field
Ornithogalum umbellatum	star of Bethlehem	Riparian Forest/Open Field
Osmorhiza claytoni	sweet cicely	Riparian Forest
Panicum clandestinum	deer tongue grass	Riparian Forest/Open Field
Phytolacca americana	pokeweed	Riparian Forest
Plantain major	common plantain	Open Field
Platanus occidentalis	sycamore	Riparian Forest
Polygonatum biflorum	smooth Solomons seal	Riparian Forest
Polygonum coccineum	swamp smartweed	River Bank

PLANTS (Continued)		
Scientific Name	**Common Name**	**Habitat**
Quercus muehlenbergii	chinkapin oak	Riparian Forest
Rhus typhina	staghorn sumac	Riparian Forest
Robina pseudoacacia	black locust	Riparian Forest/Open Field
Rosa multiflora	multiflora rose	Riparian Forest
Rubus spp.	blackberry	Riparian Forest/Open Field
Rumex crispus	curly dock	Open Field
Salix interior	sandbar willow	River Bank
Salix nigra	black willow	River Bank
Sambucus candensis	common elder	Riparian Forest
Solidago spp.	goldenrod	Open Field
Stellaria media	common chickweed	Open Field
Taraxacum officinale	dandelion	Open Field
Thalictrum polyganum	tall meadow rue	Riparian Forest
Thlaspi arvense	penny cress	Open Field
Toxicodendron radicans	poison ivy	Riparian Forest/Open Field
Tragopogon pratensis	yellow goatsbeard	Open Field
Trauvetteria carolinensis	tassel rue	Riparian Forest
Trifolium pratense	red clover	Open Field
Ulmus americana	American elm	Riparian Forest
Urtica dioica	stinging nettle	Riparian Forest
Valerianella olitoria	lamb's lettuce	Open Field
Vicia cracca	bird vetch	Open Field
Vitus spp.	grape	Riparian Forest
Total No. Plant Species = 68		

4.2 Aquatic Ecology

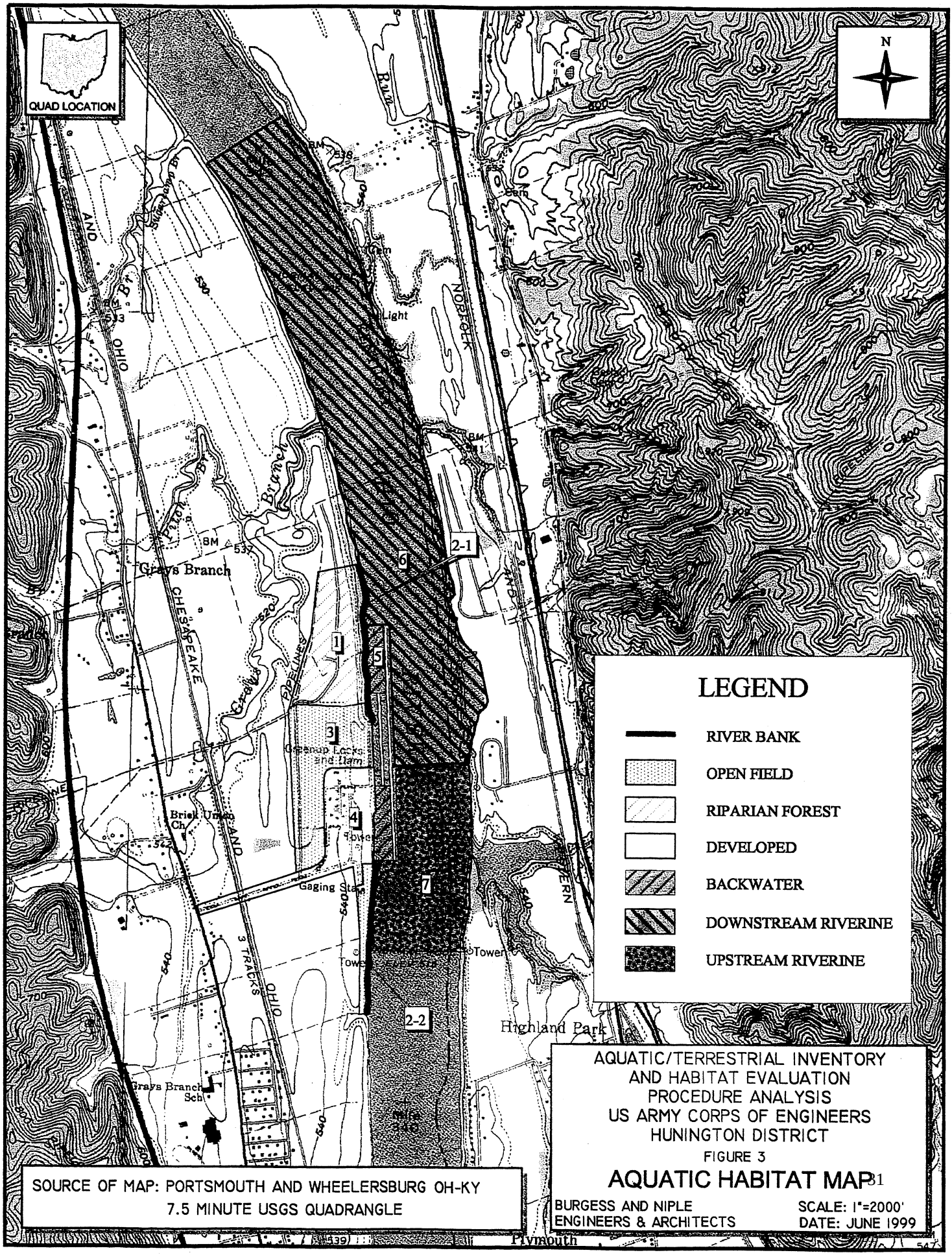
Three different habitats were encountered during the aquatic inventory conducted at Greenup Locks and Dam. These areas include two riverine zones and a simulated backwater (pool) area created by the lock structures. Aquatic habitat areas are shown on the Habitat Aquatic Map (Figure 3) with photographs included in Appendix F, and voucher specimen photographs are provided in Appendix G.

4.2.1 **Aquatic Habitats and Fish Communities**

Upstream Riverine – The upstream portion of the study area, starting at RM 340.5 and ending at the upstream limit of the lock structures, is approximately 400 meters in length and spans the area from T1 through T5. This area is characterized primarily by sand and silt substrate types with some debris. The shoreline within this zone consists of a vegetated bank with a steep slope down to the edge of the river. The riparian zone along this stretch of the river is characterized by woody debris, undercut banks, root wads, root mats, and overhanging vegetation. Water depths within this area range from two to five feet along the shore to 10 to 20 feet approximately six meters from the bank. Juvenile *Pylodictis olivaris* (flathead catfish) were collected along the vegetated shoreline. This was the only vertebrate species collected from this habitat area. Total areal extent of the Upstream Riverine habitat is 40 acres.

Downstream Riverine – The second habitat area observed during the aquatic inventory was a backwater (pool) area located around RM 341.0, spanning the area just north of T5 and just south of T6 to the lock facilities. This area is approximately 1,000 meters in length and has been created by the presence of the lock structures along the west shore of the Ohio River. This habitat is characterized by sand and silt substrate types, with a predominance of silt in these areas. The shoreline just north of T5 consists of a bank area with riprap and a vegetated shoreline around the lock facilities. Another area with similar habitat characteristics is located on the north side of the dam, just west of the lock wall and south of T6. Water depths within these areas were found to be five feet and less. Vertebrate species collected from this habitat included *Lepomis gibbosus* (pumpkinseed sunfish), *Lepomis megalotis* (longear sunfish), *Lepomis macrochirus* (bluegill), *Notropis atherinoides* (emerald shiner), *Hybopsis storeriana* (silver chub), and *Pimephales notatus* (bluntnose minnow). These species were primarily collected close to the shoreline among overhanging vegetation. Other species collected from deeper water in this area included *Micropterus salmoides* (largemouth bass), *Carpiodes carpio* (river carpsucker), *Carpiodes cyprinus* (quillback carpsucker), *Carpiodes velifer* (highfin carpsucker), *Ictalurus punctatus* (channel catfish), *Aplodinotus grunniens* (freshwater drum), *Minytrema melanops* (spotted sucker), *Ictiobus bubalus* (smallmouth buffalofish), *Alosa chrysochloris* (skipjack herring), and *Lepisosteus osseus* (longnose gar).

Total estimated areal extent of the Downstream Riverine Habitat is 210 acres.



SOURCE OF MAP: PORTSMOUTH AND WHEELERSBURG OH-KY
7.5 MINUTE USGS QUADRANGLE

AQUATIC/TERRESTRIAL INVENTORY
AND HABITAT EVALUATION
PROCEDURE ANALYSIS
US ARMY CORPS OF ENGINEERS
HUNINGTON DISTRICT

FIGURE 3

AQUATIC HABITAT MAP

BURGESS AND NIPLE
ENGINEERS & ARCHITECTS

SCALE: 1"=2000'
DATE: JUNE 1999

P:\PR2461\GIS\AQUHAB.APR ARCVIEW

Backwater – The last habitat area observed originates around RM 341.5 and extends to RM 343.0 downstream of the locks and dam. This zone is approximately 2,400 meters in length, spanning the area from T6 to T18. Substrates within this zone consist of various mixtures of clay, cobble, silt, sand, and gravel. Cobble substrates appeared to dominate in the vicinity of RM 342.0 to 343.0. The shoreline within this zone is characterized by areas of cobble and sand, with evidence of past placement of dredge material along the shoreline. Water depths within this habitat area range from five to eight feet along the shoreline dropping to around 11 feet approximately six meters from the shore. Species collected from this habitat area included *Moxostoma anisurum* (silver redhorse), *Moxostoma erythrurum* (golden redhorse), *Moxostoma duquesnei* (black redhorse), *Ambloplites rupestris* (rock bass), C*arpiodes carpio* (river carpsucker), *Lepisosteus osseus* (longnose gar), *Lepomis macrochirus* (bluegill), *Micropterus punctulatus* (spotted bass), and *Morone chrysops* (white bass). These species were primarily collected from the deeper areas with rock bass and bluegill being collected around submerged structures or vegetation. *Notropis atherinoides* (emerald shiner), *Notropis spilopterus* (spotfin shiner), *Notropis stramineus* (sand shiner), *Notropis blennius* (river shiner), and *Notropis hudsonius* (spottail shiner) were primarily collected along the shoreline in shallow water.

Total estimated aerial extent of the Backwater Habitat is 23 acres.

Dorosoma cepedianum (gizzard shad) was collected throughout the range of the aquatic inventory from RM 340.5 to RM 343.0and was concluded to be one of the most abundant vertebrate species present in the study area. In addition, a striped bass hybrid was also collected primarily in the vicinity of RM 342 to RM 343.

4.2.2 **Macroinvertebrates**

Dominant macroinvertebrates collected during the aquatic inventory included *Dreissena polymorpha* (zebra mussel), *Corbicula fluminea* (Asian clam), *Lumbriculus variegatus* (aquatic oligochaete), *Branchiura sowerbyi* (aquatic oligochaete), and *Pristina breviseta* (aquatic oligochaete). These species were collected within all habitats encountered between RM 340.5 and RM 343.0. *Hexagenia* sp. (burrowing mayfly) and *Gammarus fasciatus* (amphipod) were collected primarily from the sand/silt substrates of the area spanning T1 through T6 (approximately RM 340.5 to RM 341.5). Members of the Order Diptera, Family Chironomidae (midges) were also collected from all habitat areas

between RM 340.5 and RM 343.0. Macroinvertebrate species identified between RM 340.5 and RM 343.0 are considered to be representative of species typically occurring in large river systems. The number of species collected is primarily a function of the substrate and water conditions of the riverine zone sampled during the aquatic inventory.

4.2.3 Unionids

No unionids were found upstream of the dam or downstream to approximately RM 342.0. A narrow zone of unionids was found within 50 meters of the Kentucky bank between RM 342.0 and RM 343.0. A total of 1,230 live unionids and 18 live species was found. In all, 24 species of unionid mussels were collected during the aquatic inventory. Several live species listed as endangered in Ohio were also collected. These species include *Ellipsaria lineolata* (Elephant ear), *Lampsilis ovata* (Pocketbook), *Magalonaias nervosa* (Washboard), *Plethobasus cyphyus* (Sheepnose), *Pleurobema cordatium* (Ohio pigtoe), and *Quadrula nodulata* (Wartyback). No federally endangered species were collected live, but *Lampsilis ovata* (pocketbook), a Kentucky endangered species, and *Plethobasus cyphyus* (sheepnose), a special concern species in Kentucky, were both collected. In addition, *Obovaria retusa* (ring pink) was collected as a subfossil shell. This species is listed as endangered within the State of Kentucky and also by the U.S. F&WS. Further discussion of these three mussel species is provided in Section 4.3, Threatened and Endangered Species.

4.2.4 Aquatic Species Inventory Lists

A list of the species collected during the aquatic inventory conducted at Greenup Locks and Dam is presented below. Species have been divided into vertebrates (fish) (Table 7), macroinvertebrates (Table 8), and unionid mussels (Table 9).

Table 7. Fish species, May 1999.

Scientific Name	Common Name
Dorosoma cepedianum	Eastern Gizzard Shad
Notropis atherinoides	Common Emerald Shiner
Morone chrysops	White Bass
Lepomis megalotis	Central Longear Sunfish
Micropterus salmoides	Northern Largemouth Blackbass
Pylodictis olivaris	Flathead Catfish [1]
Lepomis macrochirus	Northern Bluegill Sunfish
Lepomis gibbosus	Pumpkinseed Sunfish
Lepisosteus osseus	Longnose Gar
Alosa chrysochloris	Skipjack Herring
Carpiodes carpio	Northern River Carpsucker
Ambloplites rupestris	Northern Rockbass [2]
Moxostoma duquesnei	Black Redhorse
Hybopsis storeriana	Silver Chub
Notropis spilopterus	Spotfin Shiner
Notropis stramineus	Sand Shiner
Notropis blennius	River Shiner
Pimephales notatus	Bluntnose Minnow
Moxostoma erythrurum	Golden Redhorse
Moxostoma anisurum	Silver Redhorse
Carpiodes cyprinus	Central Quillback Carpsucker
Ictalurus punctatus	Channel Catfish
Notropis hudsonius	Spottail Shiner
Micropterus punctulatus	Northern Spotted Blackbass
Carpiodes velifer	Highfin Carpsucker
Dorosoma petenense	Threadfin Shad
Ictiobus bubalus	Smallmouth Buffalofish
Minytrema melanops	Spotted Sucker
Aplodinotus grunniens	Freshwater Drum
Total No. Fish Species = 29	

(1) Juvenile
(2) Single individual

***Striped Bass Hybrid was also collected.

Table 8. Macroinvertebrates species, May 1999.

Order	Family	Subfamily	Genus	Species	Common Name
Veneroida	Dreissenidae	-	*Dreissena*	*polymorpha*	Zebra Mussel
Veneroida	Corbiculidae	-	*Corbicula*	*fluminea*	Asian Clam
Mesogastropoda	Hydrobiidae*	-	-	-	Gastropod
Anostraca*	-	-	-	-	Branchiopod Crustacean
Lumbriculida	-	-	*Lumbriculus*	*variegatus*	Oligochaete
Tubificida	Tubificidae	-	*Branchiura*	*sowerbyi*	Oligochaete
Ephemeroptera	Ephemeridae	-	*Hexagenia*	sp.	Mayfly
Basommatophora	Ancylidae	-	*Ferrissia*	*rivularis**	Limpet
Amphipoda	Gammaridae	-	*Gammarus*	*fasciatus*	Amphipod
Tubificida	Naididae	-	*Pristina*	*breviseta*	Oligochaete
Diptera	Chironomidae	Tanypodinae	*Ablabesmyia*	sp.	Midge
Diptera	Chironomidae	Chironominae	*Tanytarsus*	sp.	Midge
Diptera	Chironomidae	Chironominae	*Dicrotendipes*	sp.	Midge
Diptera	Chironomidae	Tanypodinae	*Thienemannimyia*	group sp.	Midge
Diptera	Chironomidae	Chironominae	*Paratanytarsus*	sp.	Midge
Diptera	Chironomidae	Tanypodinae	*Macropelopia*	sp.	Midge
Diptera	Chironomidae	Chironominae	*Polypedilum*	sp.	Midge
Diptera	Chironomidae	Chironominae	*Parachironomus*	sp.	Midge
Diptera	Chironomidae	Orthocladiinae	*Eukiefferiella*	sp.	Midge
Diptera	Chironomidae	Orthocladiinae	*Cricotopus*	sp.	Midge
Total No. Macroinvertebrate Taxa = 20					

*Single individual.

Table 9. Mussel species, May 1999.

Scientific Name	Common Name
Actinonaias ligamentina	Mucket
Amblema p. plicata	Threeridge
Ellipsaria lineolata	Butterfly
Elliptio crassidens	Elephant Ear
Elliptio dilatata	Spike
Fusconaia ebena	Ebonyshell
Fusconaia flava	Wabash Pigtoe
Lampsilis cardium	Plain Pocketbook
Lampsilis ovata	Sharp-Ridged Pocketbook
Lampsilis siliquoidea	Fatmucket
Leptodea fragilis	Fragile Papershell
Ligumia recta	Black Sandshell
Megalonaias nervosa	Washboard
Obliquaria reflexa	Threehorn Wartyback
*Obovaria retusa**	Ring Pink
Plethobasus cyphyus	Sheepnose
Pleurobema cordatum	Ohio Pigtoe
Potamilus alatus	Pink Heelsplitter
Quadrula metanevra	Monkeyface
Quadrula nodulata	Wartyback
Quadrula p. pustulosa	Pimpleback
Quadrula quadrula	Mapleleaf
Truncilla donaciformis	Fawnsfoot
Truncilla truncata	Deertoe
Total No. Mussel Species = 24	

*Collected as a subfossil shell.

4.2.5 Water Quality

Several parameters including turbidity, DO, current velocity, temperature, conductivity, and pH were measured within different habitat areas to give some idea of water quality within the study area. Measurements were taken at different depths and distances from the shoreline to give an indicator of average water quality conditions within each different habitat. Averages of these parameters are presented in Table 10 below.

Table 10. Average water quality conditions, aquatic habitat areas.

Water Quality Parameters	RM 340.5 (T1-T5)	Backwater (T5 & T6)	RM 341.5 (T7-T18)
Temperature (°C)	22	21.5	22
Dissolved Oxygen (DO mg/l)	7.6	7.7	7.9
Conductivity (mhos/cm)	422	418	388
pH	6.5	6.9	7.1
Current Velocity (m/sec)	0.16	0	0.36
Turbidity (Secchi Depth-m)	1.1	0.7	0.7

Temperature was observed to be relatively constant within all habitat areas. DO was found to be lowest at the upstream limit of the study area around RM 340.5, and was only slightly higher within the backwater habitat areas. DO was highest in the vicinity of RM 341.5 to 343.0, possibly accounting for the presence of several different vertebrate species encountered in this area which were not collected from the other habitat areas. Conductivity was very similar in the upstream portion of the study area and in backwater areas, while conductivity between RM 341.5 and RM 343.0 was somewhat lower. Between RM 340.5 and RM 343.0, pH was found to range from 6.5 to 7.1. The pH around RM 340.5 was found to be the lowest (6.5), while remaining habitat areas were found to be fairly neutral in regard to pH. As expected, backwater areas were lacking in any measurable current, while current velocities in the river channel ranged from 0.16 to 0.36 meters per second. Turbidity within habitat areas was measured using a secchi disk. As indicated by average measurements, turbidity was greatest within backwater areas and also within the habitat area between RM 342.0 and RM 343.0. Turbidity was somewhat lower around RM 340.5 as indicated by the greater secchi depth.

4.3 Threatened and Endangered Species

4.3.1 Indiana Bat Survey

The mist net survey conducted by BHE did not confirm the presence of Indiana Bat. Habitat potential was assessed as low to moderate, with scattered large cottonwoods in the mature woods providing the most likely potential roosting habitat. Three Big Brown Bat (*Eptesicus fuscus*) individuals were captured within the riparian forest outside the study area during the survey. Two individuals were pregnant females, and the third individual escaped before gender and reproductive condition could be determined. A copy of BHE's report is provided in Appendix C.

4.3.2 Mussel Survey

While conducting the mussel portion of the aquatic inventory for Greenup Locks and Dam, three species with special status within the state of Kentucky were collected by ESI between RM 342 and RM 343. *Obovaria retusa* (ring pink) was collected as a subfossil shell. This species is listed as endangered in the state of Kentucky and is also listed as endangered by the U.S. Fish & Wildlife Service. *Lampsilis ovata* (pocketbook) was collected and is also listed as a state endangered species. *Plethobasus cyphyus* (sheepnose) was collected during the aquatic inventory and is listed as a special concern species within the state of Kentucky. Only one vertebrate species with special status in Kentucky was identified during the aquatic inventory. *Notropis hudsonius* (spottail shiner) was collected during this inventory and is listed as a special concern species within Kentucky. Endangered species are defined by KSNPC as a taxon in danger of extirpation and/or extinction throughout all or a significant part of its range in Kentucky. Although species identified as "special concern" hold no state legal status, these species can be subject to monitoring for any of the following reasons:

- It exists in a limited geographic area.
- It may become threatened or endangered due to modification or destruction of habitat.
- Certain characteristics or requirements make it especially vulnerable to specific pressures.
- Experienced researchers have identified other factors that may jeopardize it.
- It is thought to be rare or declining but insufficient information exists for assignment to the threatened or endangered status categories.

A copy of the unionid inventory report prepared by ESI is included in Appendix B.

5.0 BASELINE HEP ASSESSMENT

5.1 Methodology

A modified/abbreviated HEP analysis was conducted on the study area to provide repeatable, quantified indices that can be used to evaluate the quality of the habitat for wildlife and a basis for mitigation needs. HEP methodology was first developed by the U.S. F&WS in response to the NEPA, which required all federal agencies to employ systematic and interdisciplinary techniques in planning and decision-making, and required "methods and procedures that will ensure environmental amenities and values that are presently not quantified may be given appropriate consideration in decision-making." The results of this effort and descriptions of the methodology are provided in the *Habitat Evaluation Procedures Work Book* (National Ecology Research Center, 1980) as well as several other documents including the *Ecological Services Manual* (U.S. F&WS) and its subsequent releases (*Habitat as a Basis for Environmental Assessment ESM 101, Habitat Evaluation Procedures ESM 102, Development of Habitat Suitability Indices ESM 103*). Numerous HSI Models were also prepared by the U.S. F&WS as required elements of the HEP process.

The U.S. F&WS HEP analyses were found to be very laborious and too expensive for most smaller projects. Other authors and agencies in response to this problem have developed alternative methodologies. The same basic principles, procedures, and terminology are utilized in these other methodologies; however, the HSI models and data requirements are generally simpler and quicker. One of these alternate procedures is the Pennsylvania Modified HEP known as PAM HEP (Palmer, 1980) developed by the Pennsylvania Game Commission. The Pennsylvania Game Commission also produced a number of simplified HIS models for use in the procedures.

The PAM HEP methodology formed the basis of the subject HEP analysis; however, the process was further abbreviated in that not all PAM HEP forms were prepared, and in that the procedures were restricted to address only baseline existing conditions. Full HEP analyses project into the future to assess the differences in habitat quality that occur during and directly after construction as well as up to 50 years thereafter to account for changes in the habitat due to vegetation growth and succession as well as any additional project impacts.

The process of the subject HEP analysis was as follows:

- Map and classify the habitats found on the study area through aerial photograph interpretation and ground-truthing.

- Apply compartment identification numbers to each habitat map unit or polygon on the study area.

- Conduct field studies to determine the wildlife species that are common or abundant in habitat types on the study area.

- Select Evaluation Species per PAM HEP methodology for habitat evaluation via HSI models.

- Collect field data on habitat parameters (vegetation, soils, hydrology, limnology) that are used to determine Suitability Indices (SIs) for Life Requisites based on suitability index curves presented in the existing HSI models.

- Implement HSI models to calculate HSIs for each Evaluation Species in each study area habitat compartment in which it is believed to occur.

- Calculate average HSIs for each Evaluation Species found in the habitat over all compartments.

- Calculate the number of HUs on the entire study area under existing conditions, based upon the average HSI for each species in each habitat type, and the number of acres of each habitat type on the study area.

The number of HUs within any area that would be disturbed can then serve as a basis for assessing potential impacts to the area from the project, and any mitigation needs/requirements.

5.2 Habitat Mapping

The aerial photo interpretation and ground truthing procedures used to map the habitats on the study are described in Section 2.1.1. The resulting habitat maps are provided on Figure 2 and Figure 3 for the terrestrial and aquatic portions of the study area respectively. The habitat types found on the study area are described in Section 4.1 and Section 4.2.

Per PAM HEP and U.S. F&WS HEP procedures, each habitat map unit or compartment was ascribed to one of the major habitat categories (i.e., terrestrial, aquatic) and to a land use (terrestrial habitats) or wetland (wetland and aquatic habitats) classification. These systems are provided in detail in the PAM HEP instructional manual (Palmer, 1980) and follow the classification scheme developed by Anderson et al. (1976), for remote sensing studies of terrestrial landscapes and Cowardin et al. (1979), for wetland classification. Each of these classification schemes provides a numerical identifier for each specific land use category or wetland type (see Table 11 below). For this project each compartment was also identified as being one of the specific habitat types described in the mapping efforts in Sections 4.1 and 4.2. Each compartment was also given a compartment-specific identification number. The compartments mapped on the study area, their land use/wetland classifications, and their areas, are provided below in Table 11 and are indicated on the habitat maps on Figures 1 and 2.

Table 11. Land use/habitat type classification and compartments, target year: baseline.

Habitat Category: Terrestrial			
Compartment No.	**Habitat Types**	**Land Use Category**	**Acreage**
1	Riparian Forest	415 Deciduous forest - mature	47 ac
2-1	River Bank	411 Deciduous forest - sapling	4.5 ac
2-2	River Bank	411 Deciduous forest - sapling	4.5 ac
3	Open Field	311 Mowed rangeland	83 ac
4	Developed	14 Builtup land - transportation	27 ac
Total			166 ac
Habitat Category: Aquatic			
Compartment No.	**Habitat Types**	**Land Use Category**	**Acreage**
5	Backwater	652 Lower perennial unconsolidated	23 ac
6	Lower Riverine	652 Lower perennial unconsolidated	210 ac
7	Upper Riverine	652 Lower perennial unconsolidated	40 ac
Total			273 ac
Grand Total			**439 ac**

5.3 Guilding

A guilding approach was utilized in the selection of evaluation species for the HEP analysis. The term guild refers to an abstract grouping of species according to some ecological similarity. Root (1967) first defined guilds as groups of species that utilize a common class of environmental resources in a similar way. According to this definition guilds may be species grouped together based on such things as generalized diet (omnivore, herbivore, granivore, etc.), feeding substrate (ground, aerial, foliage, bark, water surface, earth, etc.), feeding technique (grazer, gleaner, excavator, diver, scavenger, etc.), nesting/breeding site (cavity, burrow, etc.), or any number of other aspects of resource use. The present study utilizes guilding in this sense.

Guilding has also been defined as a group of species that respond similarly to perturbations in habitat conditions (Szaro, 1986). This second definition is a logical corollary of the first definition and the crux of the use of guilding in HEP analyses. If all species in a guild use a particular resource, or resources in a similar fashion, then disturbances to that resource will affect all the species in the guild similarly if not to the same degree. This is particularly true when the guilds are defined or generated for specific habitat types. Logically, one should therefore be able to assess the impact of a given activity or habitat perturbation on a few species within the guild, and then extrapolate the impact over all species in the guild. If all the species occurring in a given habitat, within a given area, are guilded, then the impact can be assessed for a few representative species from each guild, and then be extrapolated to all species in that habitat/area. Similarly, if HEP evaluation species are selected from each guild for the HEP analysis, most if not all of the impacts that the habitat perturbation will have on wildlife will be considered and assessed. The use of guild analyses in habitat assessments has, however, been a subject of debate (Sveringhaus, 1981; Thomas, 1982; Landres, 1983; Vermeer, 1984; DeGraaf and Chadwick, 1984; Szaro, 1986). The practice has been tested with respect to HEP and been found to be successful, at least for nongeneralist or specialist species (Bayer and Porter, 1989).

The guilding process for the subject study followed that indicated in the PAM HEP instructional model (Palmer, 1985), published guilding systems (DeGraaf et al., 1985), and general life history information on the subject species. Results of the guilding effort are provided below, by habitat type, in Tables 12 through 17, for all species documented as occurring on the study area during the field surveys.

Table 12. Results of guilding species observed in terrestrial riparian forest habitat.

		Diet				Feeding Site						Breeding Site					Habitat			
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Water	Ground	Air	Herbaceous Layer	Shrub Layer	Tree Layer	Water	Ground	Herbaceous Layer	Shrub Layer	Tree Layer	Riparian Forest (Woods)	River Bank (Shore)	Open Field	Evaluation Suitability Ranking
	Mallard			X		X	X						X	X			X			6
	Ruby-throated Hummingbird			X						X	X					X	X	X		6
	Cedar Waxwing			X				X			X					X	X			5
	Green Heron				X	X						X		X			X			5
	Northern Cardinal			X			X		X	X	X			X	X	X	X			9
	Blue Jay			X			X			X	X				X	X	X			7
X	Pileated Woodpecker		X				X				X					X	X			5
	Gray Catbird			X			X		X	X				X	X		X			7
	CommonYellowthroat		X						X	X				X	X		X			6
X	Wood Thrush			X			X								X	X	X			5
	Song Sparrow			X			X		X	X				X	X		X		X	8
	Great-crested Flycathcher		X					X		X	X					X	X	X		7
	Tufted Titmouse		X							X	X					X	X			5
	Indigo Bunting			X					X	X				X	X		X			6
	Hairy Woodpecker		X							X	X				X	X	X			6
	Rufous-sided Towhee			X			X		X	X					X		X			6
	Common Grackle			X			X		X						X	X	X			6
	American Redstart		X					X		X	X					X	X			6
	Carolina Wren		X						X	X					X		X			5
	Brown Thrasher			X			X		X	X					X		X			6
	American Robin			X			X			X					X	X	X			6
	Carolina Chickadee		X							X	X					X	X			5
X	Red-eyed Vireo		X							X	X					X	X	X		6
	Shorttail Shrew			X			X		X				X				X			5
	Opossum			X			X			X	X					X	X			6
	Big Brown Bat		X					X								X	X			4
X	White-tailed Deer	X					X						X				X	X	X	6
	Deer Mouse			X			X						X		X		X			5
X	Raccoon			X		X	X			X	X					X	X	X		8
	Eastern Chipmunk			X			X						X				X			4
X	Eastern Box Turtle			X			X		X				X				X			5

Table 13. Results of guilding species observed in the terrestrial river bank habitat.

		Diet				Feeding Site						Breeding Site					Habitat			
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Water	Ground	Air	Herbaceous Layer	Shrub Layer	Tree Layer	Water	Ground	Herbaceous Layer	Shrub Layer	Tree Layer	Riparian Forest (Woods)	River Bank (Shore)	Open Field	Evaluation Suitability Ranking
	Ruby-throated Hummingbird			X						X	X					X	X	X		6
	Canada Goose	X				X	X					X	X	X				X	X	8
	Common Crow			X			X									X		X		4
	American Coot			X		X							X	X				X		5
X	Belted Kingfisher				X	X							X					X	X	5
	Great-crested Flycatcher		X					X		X	X					X	X	X		7
	Double-crested Cormorant				X	X									X			X		4
X	Red-eyed Vireo		X							X	X					X	X	X		6
X	White-tailed Deer	X					X						X				X	X	X	6
X	Beaver	X				X	X					X						X		5
X	Raccoon			X		X	X			X	X					X	X	X	X	9
	Red Fox			X			X						X					X		4
	Eastern Painted Turtle			X		X						X	X					X		5

Table 14. Results of guilding species observed in the terrestrial open field habitat.

		Diet				Feeding Site						Breeding Site					Habitat			
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Water	Ground	Air	Herbaceous Layer	Shrub Layer	Tree Layer	Water	Ground	Herbaceous Layer	Shrub Layer	Tree Layer	Riparian Forest (Woods)	River Bank (Shore)	Open Field	Evaluation Suitability Ranking
	Red-winged Blackbird			X			X		X					X	X				X	6
	Canada Goose	X				X	X					X	X	X				X	X	8
X	Red-tailed Hawk				X		X									X	X		X	5
	Turkey Vulture				X		X						X						X	4
	Killdeer		X			X	X						X						X	5
	Yellow-shafted Flicker		X				X				X					X			X	5
	Barn Swallow		X					X											X	3
	Baltimore Oriole			X							X					X			X	4
	Belted Kingfisher				X	X							X					X	X	5
	Song Sparrow			X			X		X	X				X	X		X		X	8
	Purple Martin		X					X											X	3
	Eastern Bluebird		X				X		X							X			X	6
X	Eastern Meadowlark		X				X		X				X	X					X	6
	European Starling			X			X		X							X			X	5
	Mourning Dove			X			X									X			X	4
	Woodchuck	X					X						X						X	4
X	Meadow Vole			X			X						X						X	4
	Eastern Harvest Mouse			X			X						X						X	4
X	Eastern Cottontail	X					X						X						X	4

Table 15. Results of guilding species observed in aquatic backwater habitats.

		Diet				Spawning							
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Aquatic Bed	Rock/Gravel/Sand	Debris/Structure	Mud	Riverine-Upstream	Riverine-Downstream	Backwater	Evaluation Suitability Ranking
X	Eastern Gizzard Shad			X			X	X	X	X	X	X	7
	Common Emerald Shiner			X			X	X	X		X	X	6
	Central Longear Sunfish			X			X				X	X	4
X	Northern Largemouth Blackbass				X	X	X	X	X			X	6
X	Northern Bluegill Sunfish			X		X	X	X			X	X	6
	Pumpkinseed Sunfish			X		X	X	X				X	5
	Longnose Gar				X	X	X				X	X	5
	Skipjack Herring				X		X					X	3
	Northern River Carpsucker			X			X	X			X	X	5
	Silver Chub			X			X					X	3
	Bluntnose Minnow			X			X	X				X	4
	Central Quillback Carpsucker			X			X		X			X	4
	Channel Catfish			X			X	X				X	4
	Highfin Carpsucker			X			X					X	3
	Threadfin Shad			X		X	X	X				X	5
X	Smallmouth Buffalofish			X		X	X		X			X	5
	Spotted Sucker			X			X					X	3
	Freshwater Drum			X								X	2

Table 16. Results of guilding species observed in aquatic lower riverine habitats.

		Diet				Spawning				Habitat			
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Aquatic Bed	Rock/Gravel/Sand	Debris/Structure	Mud	Riverine-Upstream	Riverine-Downstream	Backwater	Evaluation Suitability Ranking
X	Eastern Gizzard Shad			X			X	X	X	X	X	X	7
	Common Emerald Shiner			X			X	X	X		X	X	6
X	White Bass				X		X				X		3
	Central Longear Sunfish			X			X				X	X	4
X	Northern Bluegill Sunfish			X		X	X	X			X	X	6
	Longnose Gar				X	X	X				X	X	5
	Northern River Carpsucker			X			X	X			X	X	5
	Northern Rockbass				X	X					X		3
	Black Redhorse			X			X				X		3
	Spotfin Shiner			X			X	X			X		4
	Sand Shiner			X			X	X			X		4
	River Shiner			X			X	X			X		4
	Golden Redhorse			X			X				X		3
	Silver Redhorse			X			X				X		3
	Spottail Shiner			X			X	X			X		4
	Spotted Blackbass				X	X	X	X			X		5

Table 17. Results of guilding species observed in aquatic upper riverine habitats.

		Diet				Spawning Substrate				Habitat			
Selected Evaluation Species	Candidate Evaluation Species	Herbivore	Insectivore	Omnivore	Carnivore	Aquatic Bed	Rock/Gravel/Sand	Debris/Structure	Mud	Riverine-Upstream	Riverine-Downstream	Backwater	Evaluation Suitability Ranking
X	Eastern Gizzard Shad			X			X	X	X	X	X	X	7
X	Flathead Catfish				X			X	X	X			4

5.4 Evaluation Species

Evaluation species were selected for HEP analysis for each habitat type based upon (1) guidelines in the PAM HEP instructional manual; (2) the guilds developed for the project (above); (3) documented occurrence of the species within the habitat on the study area; (4) the availability of existing HSI (U.S. F&WS and PAM HEP) models important game or recreational/commercial fish; and (5) whether the species was ecologically representative or characteristic of the habitat type. Secondarily, we also considered the evidence that HEP analyses work best when the evaluation species are not generalists, i.e., species that are cosmopolitan with wide niches, diets, feeding strategies, or habitat requirements. An effort was also made to include representatives from the major class taxons, i.e., mammals, birds, reptiles, amphibians, fish, where possible.

The PAM HEP instructional manual recommends that five evaluation species be selected for each major habitat category in this case (terrestrial upland, terrestrial wetland, and aquatic), and that at least two evaluation species be selected from each habitat type within the category. Habitat characterization efforts for this study determined that only two habitat categories occur on the study area – terrestrial upland and aquatic. Field surveys found three habitat types (riparian forest, field, and shoreline) on the study area that fall under the terrestrial upland category, and three habitat types (upper riverine, lower riverine, backwater) in the aquatic category.

Species were selected by habitat type first to ensure that all habitat types were represented by at least two species per the PAM HEP instructional manual. Then species were selected from the list of species observed on the study area per the five criteria listed above. Evaluation species selected specifically as representatives of the respective habitat types, and the rationale for selection, are presented in Tables 18 and 19. Each habitat type was represented by at least two species, and each habitat category was represented by at least five species.

Table 18. Evaluation species selected specifically as representative species for each terrestrial habitat type for the HEP analysis.

Land Category	Habitat Type	Evaluation Species	Selection Considerations
Terrestrial	Riparian Forest	White-tailed Deer	important game mammal, large herbivore, ground breeder, existing model
	Riparian Forest	Pileated Woodpecker	bird, cavity nester, insectivore, high ranking, requires relatively mature forests, existing model
	Riparian Forest	Wood Thrush	bird, omnivore, ground feeder, shrub nester, characteristic mature forest – especially deciduous, model exists
	Riparian Forest	Red-eyed Vireo	bird, insectivore, tree and shrub layer feeder and nester, foliage gleaner, high score, model exists
	Riparian Forest	Eastern Box Turtle	reptile, omnivore, only reptile observed in the study area, existing model
Terrestrial	Open Field	Meadow Vole	abundant, small mammal, nests on ground/subterranean, granivorous, important prey species, model exits
	Open Field	Eastern Cottontail	common on study area, nests on ground, herbivore, game mammal, prey species, model exists
	Open Field	Red-tailed Hawk	large bird, raptor, aerial/ground feeder, carnivorous, high score, tree layer nester, existing model
	Open Field	Eastern Meadowlark	bird, abundant, characteristic of field, feeds in herbaceous layer, ground nester, model exists
Terrestrial	River Bank	Beaver	semiaquatic mammal, furbearer, land/water feeder, herbivore, typical of shore/riverine habitat, model
	River Bank	Northern Raccoon	mammal, omnivore in aquatic and terrestrial habitat, typical of shore/riverine habitat, model exists
	River Bank	Belted Kingfisher	bird, piscivorous, nests in the ground, characteristic of riverine riparian habitat, specialist, model

Table 19. Evaluation species selected specifically as representative species for each aquatic habitat type for the HEP analysis.

Land Category	Habitat Type	Evaluation Species	Selection Considerations
Aquatic	Upper River	Eastern Gizzard Shad	fish, omnivore in water column, 1 of only 2 spp in upper river, important prey spp, model exists
	Upper River	Flathead Catfish	fish, top carnivore, demersal feeder, 1 of only 2 spp in upper river, model exists
Aquatic	Lower River	Northern Bluegill Sunfish	fish, small omnivore, high score, model exists
	Lower River	White Bass	fish, large carnivore, important game fish, model exists
Aquatic	Backwater	Northern Black Bass	fish, large carnivore, important game fish, high score, model exists
	Backwater	Smallmouth Buffalofish	Fish, omnivore, feeds on bottom, requires rock/sand/gravel spawn, model exists

These evaluation species were also used to evaluate any other habitat type on the study area in which they were known to occur. The total lists of evaluation species evaluated for each habitat type are presented in Table 20.

Table 20. HEP evaluation species evaluated for each habitat type on the study area, target year: baseline.

Terrestrial	**Riparian Forest**	White-tailed Deer
		Northern Raccoon
		Wood Thrush
		Red-tailed Hawk
		Red-eyed Vireo
		Pileated Woodpecker
		Eastern Box Turtle
	River Bank	White-tailed Deer
		Northern Raccoon
		Beaver
		Red-eyed Vireo
		Belted Kingfisher
		Red-tailed Hawk
	Open Field	White-tailed Deer
		Northern Raccoon
		Eastern Cottontail
		Meadow Vole
		Eastern Meadowlark
		Red-tailed Hawk
	Developed	none
Aquatic		
	Backwater	Eastern Gizzard Shad
		Northern Largemouth Blackbass
		Northern Bluegill Sunfish
		Smallmouth Buffalofish
	Lower Riverine	Eastern Gizzard Shad
		White Bass
		Northern Bluegill Sunfish
	Upper Riverine	Eastern Gizzard Shad
		Flathead Catfish

5.5 Habitat Suitability Indices (HSIs)

HSIs were calculated using data collected in the field and published HEP or HSI models for the Evaluation Species. All published models utilized for this project were from one of two sources: those published by the U.S. F&WS (Habitat Suitability Index Models or "Blue Books"), and those published by the Pennsylvania Game Commission (PAM HEP HSI Models). The source and author of the model used for each species is provided below in Table 21. The full citations of the models are provided by author in the literature cited section.

Table 21. HSI models used to evaluate the habitat.

Evaluation Species	Source	Author / Date
White-tailed Deer	PAM HEP	Palmer and Lang 1994
Northern Raccoon	PAM HEP	Palmer 1994
Beaver	U.S. F&WS	Allen 1982
Meadow Vole	PAM HEP	Palmer 1994
Eastern Cottontail	PAM HEP	Palmer 1994
Red-tailed Hawk	PAM HEP	Palmer 1994
Red-eyed Vireo	U.S. F&WS	Anonymous 1978
Wood Thrush	PAM HEP	Palmer 1994
Pileated Woodpecker	U.S. F&WS	Schroeder 1982
Belted Kingfisher	PAM HEP	Palmer 1994
Eastern Meadowlark	PAM HEP	Palmer 1994
Eastern Box Turtle	PAM HEP	McCoy 1983
Gizzard Shad	U.S. F&WS	Williamson and Nelson 1985
Flathead Catfish	U.S. F&WS	Lee and Terrell 1987
Smallmouth Buffalofish	U.S. F&WS	Edwards and Twomey 1982
White Bass	U.S. F&WS	Hamilton and Nelson 1984
Northern Bluegill	U.S. F&WS	Stuber, Gebhart and Maughan 1982
Northern Largemouth Blackbass	U.S. F&WS	Stuber, Gebhart and Maughan 1982

Each HSI model has several components which are defined below.

Life Requisite: Life requisite is a critical aspect, activity, life stage, or portion of the natural history of the species for which habitat characteristics have a bearing on the ability of the habitat to support the species. Common life requisites include food, reproduction, breeding, cover, water quality, and similar parameters.

Variable: Variables are the habitat parameters used to evaluate the suitability of a habitat in fulfilling the life requisite. Such variables or parameters include plant species composition,

foliage height, canopy closures, snag/cavity/perch density, ground cover, soil moisture, water temperature, water depth, etc.

Suitability Curves or Index Graphs: A suitability curve, developed from the scientific literature, is presented for each variable in the existing models. The suitability curve may be in the form of a linear or curvilinear regression, or some other nonlinear relationship between the status or condition of the variable and the suitability of the habitat to fulfill the life requisite.

Suitability Index: Suitability indices (SIs) are read off the suitability curve, which ranks the variable from 0.0 (not suitable) to 1.0 (optimum). SIs for each variable are entered in the HSI model, which is a mathematical expression of the relationship of the variables and their effect on suitability. The model provides an SI for each life requisite.

Habitat Suitability Index (HSI): The HSI model provides a mathematical expression of the relationship of the life requisites. The life requisite SIs are entered into the equations in the model. The result is an overall HSI for that evaluation species for that compartment of that habitat type. The HSI is in the same format as the life requisite SIs with 0.0 being unsuitable and 1.0 being optimal.

The HSIs calculated for each evaluation species in each habitat compartment on the study area are presented in Tables 22 through 28.

Table 22. Habitat compartment HSI evaluation for Riparian Forest Compartment 1.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, mature stage, shrub layer moderate-dense

Habitat Type: riparian forest

Compartment No.: 1 **Area**: 47.0 ac

Topography: nearly level to gently rolling

Tree Cover: silver maple, box elder, American elm

Shrub Cover: box elder, American elm,

Herbaceous Cover: cleavers, wingstem, poison ivy, wood nettle

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
white-tailed deer	food	0.750	0.166
	cover	0.166	
	limiting factors		
northern raccoon	breeding	0.250	0.250
	food	0.583	
	water	1.000	
	limiting factors		
wood thrush	breeding	0.500	0.400
	food	0.833	
	cover	0.400	
	limiting factors		
red-tailed hawk	food	0.950	0.950
	breeding	1.000	
	limiting factors		
red-eyed vireo	reproduction/cover	0.841	0.707
	food value	0.707	
	limiting factors		
pileated woodpecker	food/cover/reprod	0.132	0.132
	limiting factors		
eastern box turtle	breeding	1.000	1.000
	cover	1.000	

Table 23. Habitat compartment HSI evaluation for River Bank Compartment 2-1.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, pole stage, shrub layer moderate-dense

Habitat Type: river bank

Compartment No.: 2-1 **Area:** 4.5 ac

Topography: steep to nearly level

Tree Cover: black willow

Shrub Cover: black willow

Herbaceous Cover: field horsetail, lambs quarters, beggar's tick

Evaluation Species	Life Requisite	Requisite Ranking A B C	HIS
white-tailed deer	food	0.750	0.166
	cover	0.166	
	limiting factors		
northern raccoon	breeding	0.250	0.250
	food	0.583	
	water	1.000	
	limiting factors		
beaver	winter food	1.000	0.500
	water	0.500	
	limiting factors		
red-eyed vireo	reproduction/cover	0.000	0.000
	food	0.000	
	limiting factors		
belted kingfisher	breeding	1.000	0.825
	food/cover	0.825	
	limiting factors		

Table 24. Habitat compartment HSI evaluation for River Bank Compartment 2-2.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, deciduous forest, pole stage, shrub layer moderate-dense

Habitat Type: river bank

Compartment No.: 2-2 **Area:** 4.5 ac

Topography: steep to nearly level

Tree Cover: black willow

Shrub Cover: black willow

Herbaceous Cover: field horsetail, lambs quarters, beggar's tick

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
white-tailed deer	food	0.750	0.166
	cover	0.166	
	limiting factors		
northern raccoon	breeding	0.250	0.250
	food	0.583	
	water	1.000	
	limiting factors		
beaver	winter food	1.000	0.500
	water	0.500	
	limiting factors		
red-eyed vireo	reproduction/cover	0.000	0.000
	food	0.000	
	limiting factors		
belted kingfisher	breeding	1.000	0.825
	food/cover	0.825	
	limiting factors		

Table 25. Habitat compartment HSI evaluation for Open Field Compartment 3.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: terrestrial, herbaceous rangeland, mowed areas

Habitat Type: Open Field

Compartment No.: 3 **Area:** 83.0 ac

Topography: nearly level to gently rolling

Tree Cover: none

Shrub Cover: none

Herbaceous Cover: fescue

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
white-tailed deer	food	1.000	0.750
	cover	0.750	
	limiting factors		
northern raccoon	breeding	0.500	0.400
	food	0.400	
	water	1.000	
	limiting factors		
eastern cottontail	breeding	0.500	0.400
	cover	0.400	
	limiting factors		
meadow vole	food/cover	0.775	0.775
	limiting factors		
red-tailed hawk	food	1.000	0.833
	breeding	0.833	
	limiting factors		
eastern meadowlark	breeding/cover	0.880	0.880

Table 26. Habitat compartment HSI evaluation for Backwater Compartment 5.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Backwater

Compartment No.: 5 **Area**: 23 ac

Bathymetry: nearly level; water depth 5-11 ft

Description: substrate mixture of clay, silt, cobble, sand, gravel

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
eastern gizzard shad	food	0.800	0.700
	water quality	0.800	
	reproduction	0.700	
	limiting factors		
northern largemouth	food	0.477	0.772
blackbass	cover	0.857	
	water quality	0.670	
	other	1.000	
	limiting factors		
northern bluegill	food	0.794	0.878
sunfish	cover	0.750	
	water quality	0.853	
	reproduction	1.000	
	other	0.900	
	limiting factors		
small mouth buffalo fish	food/cover	0.632	0.765
	water quality	0.900	
	reproduction	0.877	
	other	0.525	
	limiting factors		

Table 27. Habitat compartment HSI evaluation for Lower Riverine Compartment 6.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Lower Riverine

Compartment No.: 6 **Area:** 210 ac

Bathymetry: nearly level; 1-5 ft water depth

Description: substrate sand and silt; shoreline riprap and vegetation

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
eastern gizzard shad	food	0.800	0.466
	water quality	0.800	
	reproduction	0.466	
	limiting factors		
white bass	food	1.000	0.559
	cover	0.466	
	water quality	0.375	
	limiting factors		
northern bluegill	food	0.707	0.883
sunfish	cover	0.850	
	water quality	0.874	
	reproduction	1.000	
	other	0.900	
	limiting factors		

Table 28. Habitat compartment HSI evaluation for Upper Riverine Compartment 7.

Project: Greenup Lock and Dam Expansion

Land Use / Cover Type: aquatic, lower perennial, unconsolidated bottom

Habitat Type: Upper Riverine

Compartment No.: 7 **Area:** 40 ac

Bathymetry: nearly level;

Description:

Evaluation Species	Life Requisite	Requisite Ranking A B C	HSI
eastern gizzard shad	food	0.800	0.466
	water quality	0.800	
	reproduction	0.466	
	limiting factors		
flathead catfish	adult cover	0.570	0.570
	limiting factors		

5.6 Baseline Habitat Units (HUs)

An HU is defined as the equivalent of 1.0 acres of habitat with an HSI value of 1.0 (optimal habitat). HUs are calculated for compartments as the product of the HSI for a given species in that compartment and the number of acres in the compartment (HUs = HSI x acres). Because an HU is an equivalent measure, 1.0 HU may be represented by 1.0 acres of habitat with an HSI of 1.0, 2.0 acres of habitat with an HSI of 0.5, or any other combination with a product of 1.0.

Table 29 lists the baseline conditions for the terrestrial habitat on site with a total HUs of 629.235. Table 30 lists the baseline conditions for the aquatic habitat on site with a total HUs of 524.925.

Table 29. Baseline conditions HUs for each evaluation species for each terrestrial habitat type on the study area and for the entire study area.

Evaluation Species	Habitat Type	HSI Value	Acreage	Habitat Units
White-tailed Deer	Riparian Forest	0.166	47.0	7.802
	River Bank	0.166	9.0	1.494
	Open Field	0.750	83.0	62.250
	Species Total			71.546
Northern Raccoon	Riparian Forest	0.250	47.0	11.750
	River Bank	0.250	9.0	2.250
	Open Field	0.400	83.0	32.200
	Species Total			47.200
Beaver	River Bank	0.500	9.0	4.500
	Species Total			4.500
Meadow Vole	Open Field	0.775	83.0	64.325
	Species Total			64.325
Eastern Cottontail	Open Field	0.833	83.0	69.139
	Species Total			69.139
Red-tailed Hawk	Riparian Forest	0.950	47.0	44.650
	Open Field	0.833	83.0	69.139
	Species Total			
Wood Thrush	Riparian Forest	0.400	47.0	18.800
	Species Total			18.800
Red-eyed Vireo	Riparian Forest	0.707	47.0	32.229
	River Bank	0.000	9.0	0.000
	Species Total			32.229
Pileated Woodpecker	Riparian Forest	0.132	47.0	6.204
	Species Total			6.204
Belted Kingfisher	River Bank	0.825	9.0	7.425
	Species Total			7.425
Eastern Meadowlark	Open Field	0.880	83.0	73.040
	Species Total			73.040
Eastern Box Turtle	Riparian Forest	1.000	47.0	47.000
	Species Total			47.000
All Species	**Project Area Total**		**434.0**	**629.235**

Table 30. Baseline conditions HUs for each evaluation species for each aquatic habitat type on the study area and for the entire study area.

Evaluation Species	Habitat Type	HIS Value	Acreage	Habitat Units
Eastern Gizzard Shad	Backwater	0.800	23.0	18.400
	Lower Riverine	0.466	210.0	97.860
	Upper Riverine	0.466	40.0	18.640
	Species Total		273.0	134.900
White Bass	Lower Riverine	0.599	210.0	125.790
	Species Total			125.790
Northern Blackbass	Backwater	0.792	23.0	18.216
	Species Total			18.216
Northern Bluegill Sunfish	Backwater	0.878	23.0	20.194
	Lower Riverine	0.883	210.0	185.430
	Species Total			205.624
Smallmouth Buffalo	Backwater	0.765	23.0	17.595
	Species Total			17.595
Flathead Catfish	Upper Riverine	0.570	40.0	22.800
	Species Total			22.800
All Species	**Project Area Total**		**273.0**	**524.925**

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APPENDIX A

SCIENTIFIC WILDLIFE COLLECTING PERMIT

COMMONWEALTH OF KENTUCKY
DEPARTMENT OF FISH AND WILDLIFE RESOURCES
C. THOMAS BENNETT, COMMISSIONER

May 6, 1999

Ms. Jennifer Lynn Kelly, Environmental Scientist
Burgess and Niple, Limited
5085 Reed Road
Columbus, OH 43220

Dear Ms. Kelly:

The Kentucky Department of Fish and Wildlife Resources (KDFWR) has entered into a cooperative agreement with the U. S. Fish and Wildlife Service pursuant to Section 6(c) of the Endangered Species Act of 1973 as amended, 15 U.S.C. Sections 1531-43 (hereinafter referred to as "the Act"), which enables its employees or agents to take federally endangered or threatened species, under specific conditions, for conservation purposes consistent with the purposes of the Act.

KDFWR has determined that your activity is in compliance with the Act and information gained may enhance the conservation of endangered or threatened species. Therefore, KDFWR is designating you as an agent of the Kentucky Department of Fish and Wildlife Resources. As such you will be responsible for adherence to the following provisions: no taking or collecting of federally threatened or endangered species will be allowed which will result in 1) the death or permanent disabling of the specimens; 2) the removal of the specimens from the state of Kentucky; 3) the introduction of the specimen or any of its progeny into an area beyond the historical range of the species; or 4) the holding of the specimen in captivity for a period of more than 45 consecutive days. Salvaged shells of dead threatened or endangered mussels, however, may be retained in your reference collection.

In order to facilitate your work, the following individuals listed on your collecting permit (Katherine E. Fontaine) may also participate in activities pertaining to threatened or endangered species according to the provisions detailed above. You, however, will be singularly responsible for making them aware of the provisions of this agent designation, 301 KAR 4:070 and all requirements assigned accordingly.

This designation will be effective until December 31, 1999. A copy of this letter shall be retained in the possession by yourself or others when in the field during collection trips.

If you should have any questions, please feel free to contact me.

Sincerely,

Roy A. Grimes
Director
Wildlife Division

RAG:djc
cc: David Loveless
Pete Pfeiffer
Wayne Davis
Dan Figert
Earl Gray

KENTUCKY SCIENTIFIC WILDLIFE COLLECTING PERMIT

This permit authorizes Jennifer Lynn Kelly, Environmental Scientist
(Name) (Title)

Burgess and Niple, Limited
(Name of Company)

5085 Reed Road, Columbus, OH 43220 614/459-2050 work 614/870-9512 home
(Address) (Zip) (Phone)

to collect the fish and wildlife species necessary to evaluate an area of land and/or water for the below stated purpose, except those species designated as threatened or endangered by state or federal law. This permit does not authorize the taking of any species for personal use or consumption. Sport fishing gear may not be possessed in the field while collecting. All collecting equipment, except firearms, while in use or being transported, must be marked with the permittee's name and address. Additions or deletions to the permit may be requested by letter or phone. Violation of fish and wildlife laws, or the provisions of this permit by any collector, will be grounds for revocation, without compensation, of this permit. A copy of this permit may be assigned to the persons named below. *Permittees should contact local conservation officers before collecting in their county.*

NAME OF OTHER PERSONS INVOLVED IN COLLECTIONS: Katherine E. Fontaine

PURPOSE OF COLLECTION: An environmental assessment; Obtaining taxonomic and distribution data and specimens.

SPECIES OR GROUPS OF FISH/WILDLIFE; NUMBERS: Fish, macroinvertebrates-aquatic, mussels, small mammals, birds.

COLLECTING EQUIPMENT AUTHORIZED: for wildlife: live traps, mist nets. For Fish: electrofishing.

COLLECTING LOCALITY: Collectors must notify the Daniel Boone National Forest Supervisor when collecting on National Forest Lands. Greenup County, KY.

DISPOSITION OF SPECIMENS AND/OR SPECIAL CONDITIONS: All collected specimens must be returned to the environment where collected, preserved for study or voucher, or disposed of by burying. Zebra mussels must NOT be returned to any KY waters.

THIS PERMIT EXPIRES: DECEMBER 31, ~~1998~~ 1999

Director, Division of Fisheries

Director, Division of Wildlife

C. Tom Bennett

Commissioner, Department of Fish and Wildlife Resources

xc: Environmental Section Chief
Major Earl Gray, Law Enforcement

APPENDIX B

ECOLOGICAL SPECIALISTS, INC. - UNIONID COMMUNITY CHARACTERIZATION

Characterization of a Unionid Community near Greenup Locks and Dam: Ohio River Miles 340.5 to 343.0

Prepared for:
Burgess & Niple, Limited
Columbus, Ohio

Under Contract with:
U.S. Army Corps of Engineers, Huntington District
Huntington, West Virginia

Prepared by:
Ecological Specialists, Inc.
St. Peters, Missouri

June 1999

(ESI Project # 99-007)

Acknowledgements

This survey was conducted under contract to Burgess & Niple, Limited. Mr. David Mitchell served as Burgess & Niple's project manager. Ms. Heidi Dunn managed the project for Ecological Specialists, Inc. (ESI). Mr. Dan Kelner was ESI's field team leader. He was assisted by Mr. Bernard Sietman (ESI). Diving was conducted by Mainstream Commercial Divers, Inc. Mr. Sietman, Mr. Kelner, and Ms. Dunn prepared this report.

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1.0 Introduction

The U.S. Army Corps of Engineers (USCOE) proposes extending the lock wall at Greenup Locks and Dam on the Ohio River. With the improving water and sediment quality in recent years (Cavanaugh and Mitsch, 1989; Pearson and Pearson, 1989; Youger and Mitsch, 1989), unionids have begun to flourish in many areas of the Ohio River. Recent studies have recorded 41 living and recently dead species in the upper river, 30 of which are present in Meldahl Pool (Table 1-1). These unionid communities are often diverse and the Federally listed species *Cyprogenia stegaria* and *Lampsilis abrupta* have been found in several areas (ESI, 1996a, 1996b, 1998a, and 1998b; Miller and Payne, 1995; P. Morrison-USFWS, pers. comm.).

USCOE is concerned that unionids may be affected by construction activities during lock wall modification. Unionids could be affected by construction activities in several ways. Unionids living in the construction area could be crushed or dislodged during sheet piling placement and removal, and lock wall construction. Cofferdam dewatering and removal may result in substrate disturbance and downstream siltation. Construction activities (such as staging equipment near banks and in the water, barge spudding, etc.) will also crush or dislodge animals, or disturb substrate and streambanks, possibly resulting in downstream sediment deposition. Additionally, fish host activity in a unionid bed may be altered by habitat changes and/or altered flow patterns.

Based on available information, the Kentucky side of the Ohio River between Ohio River Mile (ORM) 340 and 343 has never been sampled for unionids. USCOE therefore contracted Burgess & Niple and Ecological Specialists, Inc. to survey for unionids along the left descending bank of the Ohio River upstream and downstream of Greenup Locks and Dam. The objective of the study was to determine unionid species composition, relative abundance, and distribution within the study area.

Table 1-1. Recent unionid species records in the upper Ohio River.

Species[1]	Common Name	Status[2]	ORM 0 to 418.9[3,4]	Meldahl Pool [3,5]
Actinonaias ligamentina	mucket		L	L
Amblema p. plicata	threeridge		L	L
Cyclonaias tuberculata	purple wartyback		L	L
Cyprogenia stegaria	fanshell	FE,KYE,OE	L	
Ellipsaria lineolata	butterfly	OE	L	L
Elliptio crassidens	elephant-ear	OE	L	L
Elliptio dilatata	spike		L	L
Epioblasma t. torulosa	tubercled blossom	FE,KYE	SF	
Epioblasma triquetra	snuffbox	C2,KYS	FD	
Fusconaia ebena	ebonyshell		L	L
Fusconaia flava	Wabash pigtoe		L	L
Fusconaia subrotunda	long-solid	OE,KYT	L	
Lampsilis abrupta	pink mucket	FE,KYE,OE	L	
Lampsilis cardium	plain pocketbook		L	L
Lampsilis ovata	pocketbook	KYE,OE	L	L
Lampsilis siliquoidea	fatmucket		L	L
Lampsilis teres	yellow sandshell	OE	L	L
Lasmigona c. complanata	white heelsplitter		L	L
Lasmigona costata	fluted-shell		L	
Leptodea fragilis	fragile papershell		L	L
Ligumia recta	black sandshell		L	L
Megalonaias nervosa	washboard	OE	L	L
Obliquaria reflexa	threehorn wartyback		L	L
Obovaria olivaria	hickorynut	OE	SF	
Obovaria retusa	ring pink	FE,KYE	WD	SF
Obovaria subrotunda	round hickorynut		L	
Plethobasus cicatricosus	white wartyback	FE	SF	
Plethobasus cooperianus	orange-foot pimpleback	FE,KYE,OE	WD	
Plethobasus cyphyus	sheepnose	KYS,OE	L	L
Pleurobema clava	clubshell	FE,KYE,OE	SF	
Pleurobema coccineum	round pigtoe		L	L
Pleurobema cordatum	Ohio pigtoe	OE	L	L
Pleurobema plenum	rough pigtoe	FE,KYE	SF	
Pleurobema pyramidatum	pyramid pigtoe	C2,KYE	SF	
Potamilus alatus	pink heelsplitter		L	L
Potamilus ohiensis	pink papershell		L	FD
Ptychobranchus fasciolaris	kidneyshell		SF	
Pyganodon grandis	giant floater		L	L
Quadrula metanevra	monkeyface	OE	L	L
Quadrula nodulata	wartyback	OE	L	L
Quadrula p. pustulosa	pimpleback		L	L
Quadrula quadrula	mapleleaf		L	L
Simpsonaias ambigua	salamander mussel	C2,KYT	FD	
Strophitus undulatus	squawfoot		L	
Toxolasma parvus	lilliput		L	
Tritogonia verrucosa	pistolgrip		L	L
Truncilla donaciformis	fawnsfoot		L	L
Truncilla truncata	deertoe		L	L
Utterbackia imbecillis	paper pondshell		L	
Uniomerus tetralasmus	pondhorn		L	
Total Species			50	31
Species Live (L and FD)			41	30
Species Weathered (WD and SF)			9	1

[1]Nomenclature follows Turgeon *et al.* (1988) and Hoeh (1990)

[2]FE=Federally Endangered (USFWS, 1996); C2=Former category 2 species (USFWS,1991); KYE=Kentucky Endangered, KYT=Kentucky Threatened, KYS=Kentucky Species of Special Concern (Kentucky State Nature Preserves Commission, 1994); OE=Ohio Endangered (ODNR, 1995)

[3]Best Condition; L=Live, FD=Freshly Dead Shell, WD=Weathered Shell, SF=Subfossil Shell

[4]Taylor (1980), Tolin and Schettig (1983), Zeto *et al.* (1987), ESE (1995), ESI (1990, 1991, 1993, 1994a, 1994b, 1995a, 1996a, 1996b, 1997, 1998a, 1998b, 1998c), Miller and Payne (1995), P. Morrison (pers. comm.), W. Tolin (pers. comm.)

[5]ESI (1998c), P. Morrison (pers. comm.)

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2.0 Methods

Unionids were sampled in the Ohio River upstream and downstream Greenup Locks and Dam (ORM 340.5 to 343.0) Greenup County, Kentucky, from 13 to 17 May 1999. The main objective of this study was to determine if Federally endangered species would be affected by this project. The effort required to find uncommon species is often considerable, and they are rarely collected in brail or quantitative samples (Kovalak *et al.*, 1986, Strayer *et al.*, 1997). Timed searches yield a better estimate of unionid species richness than quantitative samples (Strayer *et al.*, 1997; Vaughn *et al.*, 1997), as well as providing relative abundance per unit of effort. Semi-quantitative sampling (timed visual and tactual searches within a given area) are less time consuming and generally yield a greater number of unionids than quantitative samples, while providing a relative idea of unionid distribution (Dunn, in press). Therefore, semi-quantitative sampling was used to estimate species composition and distribution of the unionid community. Additional qualitative timed searches were conducted in areas of unionid concentrations to increase the probability of finding rare or endangered species.

Semi-quantitative sampling was conducted along transect lines laid perpendicular to the left descending riverbank (Figure 2-1). Upstream of Greenup Locks and Dam water depth exceeded safe limits (12m) beyond 50m of the riverbank. Therefore, transects were limited to 50m long, but were spaced 100m apart from ORM 340.5 to the lock wall (five transects). Downstream of Greenup Locks and Dam, 13, 150m long transects spaced 200m apart were established perpendicular to the bank between the downstream end of the lock wall and ORM 343.0. No sampling was conducted within the restricted area of the dam (see Figure 2-1). Transects were marked at 10m intervals, and a 1m corridor within each interval (1 x 10m) was searched visually and tactually for four minutes and treated as a separate sample. General substrate composition was visually characterized by the diver in each interval and relayed to the surface crew.

To better characterize the unionid community, additional qualitative sampling was conducted in areas of unionid concentrations (between 10 and 30m from the bank and between Transects 11 and 16) until 1000 or more live unionids were collected. Additionally, the entire shoreline from Transect 11 to 18 was searched for shells.

All live unionids were identified, measured (length in mm), aged (external annuli count), and weighed (grams). Empty shells were also collected, identified, and categorized as freshly dead (nacre still lustrous, probably died within the last year), weathered (nacre chalky, probably dead more than a few months), or subfossil (periostracum eroded or shell fragmented, probably dead >10 years).

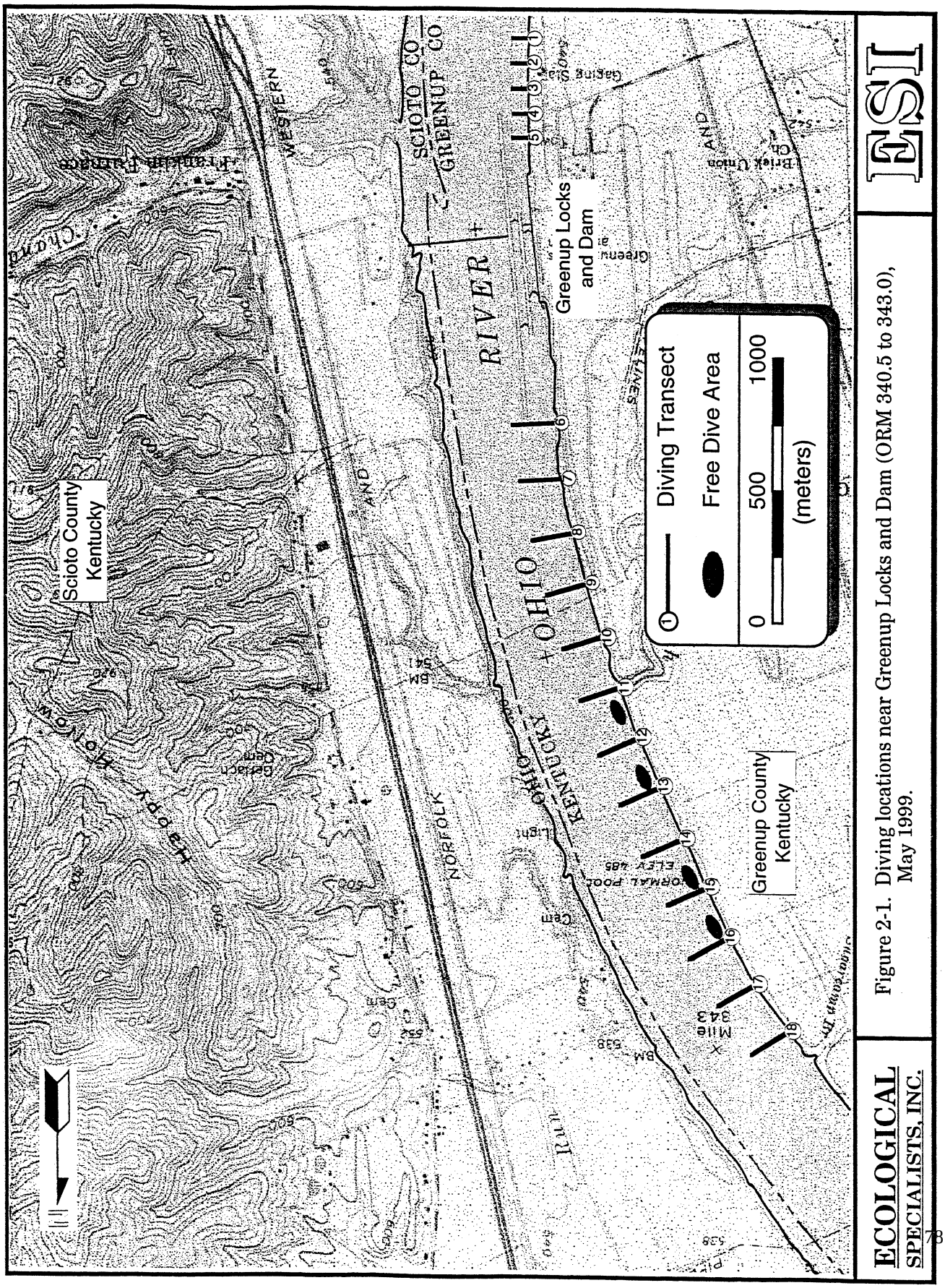

Figure 2-1. Diving locations near Greenup Locks and Dam (ORM 340.5 to 343.0), May 1999.

3.0 Results and Discussion

3.1 Habitat Characteristics and Sampling Conditions

Habitat differed considerably upstream and downstream of the locks and dam. Upstream, current velocity was <0.1 knots, and water depth averaged 5m within 50m of the bank, but was >12m at 50m. Substrate consisted primarily of fine depositional sediment (Table 3-1).

Downstream of the lock, water was shallower, averaging 2.8m (range 1.2 to 4.0m) within 50m of the bank, and 3.6m (range 1.2 to 4.9m) between the bank and 150m. Current velocity ranged from 0.5 knots near the lock to 2.2 knots downstream of Transect 10. Substrate was coarser downstream of the dam due to increased flow. However substrate characteristics varied with distance from the lock and distance from the bank. Substrate was more heterogeneous within 50m of the bank, and contained finer sediment and wood debris, particularly along Transects 6 to 10. Substrate was primarily cobble, gravel, and sand between 50 to 100m. Beyond 100m substrate was less hospitable as bedrock, boulder, and large cobble were prevalent. Additionally, several mounds of gravel were noted between Transects 13 and 18 that appeared to be a result of previous dredging activity. However, divers did not note obvious recent disturbances to the substrate within this area.

3.2 Unionid Fauna

A diverse and reproducing unionid bed is present within the study area, however unionids were primarily collected within 50m of the bank and downstream of Transect 11 (Table 3-2). No live individuals or shells were collected along Transects 1 to 5 upstream of the dam. This is likely due to the fine sediment and lack of flow associated with impoundment (Bates, 1962; Suloway *et al.*, 1981; ESI, 1995b).

Unionids were also absent downstream of the dam from Transects 6 to 8, and only one individual was collected between Transects 9 and 10 (see Table 3-2). The lack of unionids immediately downstream of the lock may be due to disturbance from towboat and barge activity. Miller and Payne's (1998) study suggest no measurable effects of commercial traffic on unionids, however they indicate that effects are dependent on vessel size, substrate, and depth and that each situation should be evaluated independently. Alternatively, the lack of unionids in this area could be due to hydrology which affects substrate characteristics. During low flow, most of the discharge from the dam is through the hydropower turbines located near the Ohio bank. Flow out of the turbines appears to be directed at an angle toward the Kentucky bank, increasing current velocity downstream of Transect 10. Flow immediately downstream of the lock on the other hand is primarily a result of released lock water, and current velocity is much slower.

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A unionid bed appears to begin near ORM 342.0, and nearly all live individuals were collected between

Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam (ORM 342.5 to 343.0) May, 1999.

Transect	Distance from Bank (m) 0-50 Substrate	0-50 Depth (m)	50-100 Substrate	50-100 Depth (m)	100-150 Substrate	100-150 Depth (m)	Date	Temp. (C°)	Dissolved Oxygen (ppm)	Secchi (mm)
1	mud/cobble/ gravel	5.0					5/13/99	20.5	8.8	1500
2	mud	5.0					5/13/99	20.5	8.8	1500
3	mud	5.0					5/13/99	20.5	8.8	1500
4	mud	5.0					5/13/99	20.5	8.8	1500
5	mud	5.0					5/13/99	20.5	8.8	1500
6	bedrock/sand/ mud	4.0	bedrock/gravel/ sand	4.5	bedrock/cobble/ sand	4.3	5/13/99	20.5	8.8	1500
7	cobble/gravel/ sand	3.7	bedrock/cobble/ sand	4.6	bedrock/cobble/ gravel/sand	4.3	5/13/99	20.5	8.8	1500
8	cobble/gravel/ sand/wood debris	3.1	gravel/sand	4.5	bedrock/cobble sand	4.7	5/13/99	20.5	8.8	1500
9	boulder/gravel/ sand/wood debris	3.7	cobble/gravel/ sand	4.3	cobble/gravel/ sand	4.7	5/14/99	20.0	9.0	1000
10	gravel/sand/silt	2.7	cobble/sand	4.3	cobble/sand	4.6	5/14/99	20.0	9.0	1000
11	cobble/sand/ zebra mussels	2.8	cobble/sand	4.0	cobble/sand	4.7	5/14/99	20.0	9.0	1000
12	cobble/sand/silt/ zebra mussels	3.2	cobble/sand	4.1	cobble/sand	4.3	5/14/99	20.0	9.0	1000
13	cobble/sand/silt/ zebra mussels	2.6	cobble/sand	4.5	bedrock/boulder/ sand	4.9	5/14/99	20.0	9.0	1000
14	sand/silt/ wood debris	1.6	cobble/sand	3.7	bedrock/boulder/ sand	4.4	5/15/99	20.0	9.1	1500
15	cobble/sand/silt/ zebra mussels	2.2	cobble/sand	4.3	cobble/sand	4.7	5/15/99	20.0	9.1	1500
16	cobble/gravel/sand/ zebra mussels	2.6	cobble/gravel/ sand	4.3	boulder/gravel/ sand	4.9	5/15/99	20.0	9.1	1500
17	cobble/gravel/sand/ zebra mussels	3.2	cobble/gravel/ sand	4.5	cobble/sand	4.7	5/16/99	20.0	9.1	1800
18	cobble/gravel/sand/ silt/zebra mussels	1.2	cobble/gravel/ sand/clay	3.3	cobble/gravel/ sand/wood debris	4.7	5/16/99	20.0	9.1	1800

Table 3-2. Unionid abundance along transects near Greenup Locks and Dam (ORM 340.5 to 343.0), May 1999.

Species	Transect 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Amblema p. plicata						SF					1	5	1		2	FD	2	3	14
Ellipsaria lineolata												1	2		2		1		6
Elliptio crassidens																WD			WD
Lampsilis cardium									1		WD		1			1		3	6
Ligumia recta											1		WD	1		2		4	8
Obliquaria reflexa									WD		1	10	3	1	15	FD	1	6	37
Potamilus alatus						WD			WD	WD	FD	1	1	WD	WD	1		2	5
Quadrula metanevra											2	7	5	1	6		2	1	24
Quadrula p. pustulosa									WD	FD	1	4	2		2			2	11
Quadrula quadrula												1	1				2		4
Truncilla truncata												WD		1					1
Total	0	0	0	0	0	0	0	0	1	0	6	29	16	4	27	4	8	21	116
No. live species	0	0	0	0	0	0	0	0	1	0	5	7	8	4	5	3	5	7	10
Total species	0	0	0	0	0	0	0	0	4	2	7	8	9	5	6	6	5	7	11
CPUE (No./10min)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.0	4.8	2.7	0.7	4.5	0.7	1.3	3.5	1.1
Density (No./m^2)[1]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<0.1	0.0	<0.1	0.2	0.1	<0.1	0.2	<0.1	0.1	0.1	<0.1

[1]Approximate density based on 15 1x10m qualitative samples per transect

Transects 11 and 18 and within 50m of the bank (see Figure 2-1 and Table 3-2). A total of 112 of the 116 live unionids of 10 species collected in semi-quantitative samples were found within 50m of the bank between Transects 11 to 18. CPUE in this area averaged 7.0 unionids/10min and density averaged 2.8 unionids/m^2 (Table 3-3). An additional 1,114 live unionids of 17 species were collected during qualitative searches between 20 and 50m from the bank and between Transects 11 and 16.

The location of this unionid bed with respect to the dam and the bank is probably due to higher current velocity downstream of Transect 10, as a result of hydropower release, and the greater heterogeneity of substrate composition and less coarse sediment near the bank (see Table 3-1). Unionids are usually more abundant near the bank in large rivers than in the river channel (Way *et al.*, 1989; Miller and Payne, 1993; ESI, 1994c). Additionally, unionid beds are usually found in areas of stable sand, gravel, and cobble substrate which is typically indicative of suitable unionid habitat (Strayer and Ralley, 1991; Vaughn, 1997). The greater amount of sedimentary material near the bank, and a preponderance of bedrock near the channel suggest substrate was more suitable for unionids near the bank. This was also the area zebra mussels (*Dreissena polymorpha*) were most abundant, and divers noted a positive relationship between the distribution of unionids and zebra mussels. Unionids were rarely found in areas without zebra mussels.

No live Federally listed species were collected, however, a subfossil shell of the Federally endangered *Obovaria retusa* was collected during the bank search. Several live species listed as endangered in Ohio or Kentucky were also collected (*Ellipsaria lineolata*, *Lampsilis ovata*, *Megalonaias nervosa*, *Plethobasus cyphyus*, *Pleurobema cordatum*, and *Quadrula nodulata*). *Obliquaria reflexa* (34.6%), *Quadrula p. pustulosa* (15.8%), *Quadrula metanevra* (15.1%), and *Amblema p. plicata* (11.5%) dominated the community (Table 3-4). *Ellipsaria lineolata* (6.8%), *Quadrula quadrula* (5.1%), *Ligumia recta* (3.7%), *Lampsilis cardium* (3.6%), and *Potamilus alatus* (2.1%) were also relatively common, while the remaining species comprised less than 1% of the community. Species collected in this study which are relatively uncommon in the upper Ohio River include *Elliptio dilatata*, *L. ovata*, *P. cyphyus*, and *Q. nodulata*. Whereas, species which are usually found in the upper Ohio River that were absent in this study included *Fusconaia flava*, *Leptodea fragilis*, and *Lasmigona c. complanata.*

The methods used in this study (semi-quantitative and qualitative) are typically biased toward larger animals and juveniles are generally under represented in samples (Payne *et al.*, 1997; Vaughn *et al.*, 1997). Juvenile unionids were not common in this study (7.6% of individuals were ≤5 years old), however juveniles ≤3 years old and ≤5 years old were collected for 33.3% and 66.7% of the live species collected, respectively (Table 3-4); indicating that successful recruitment is occurring for most species.

Table 3-3. Comparison of unionid abundance and distribution along Transects 11 to 18.

Species	0 to 50 Meters[1]			50 to 100 Meters			100 to 150 Meters			Total		
	(n)	%	(No./10min.)	(n)	%	(No./10min.)	(n)	%	(No./10min.)	(n)	%	(No./10min.)
Amblema p. plicata	14	12.5	0.9							14	12.2	0.2
Ellipsaria lineolata	6	5.4	0.4							6	5.2	0.1
Elliptio crassidens				WD						WD		
Lampsilis cardium	5	4.5	0.3	1	33.3	0.1				6	5.2	0.1
Ligumia recta	7	6.3	0.4							7	6.1	0.1
Obliquaria reflexa	36	32.1	2.3	1	33.3	0.1				37	32.2	0.6
Potamilus alatus	5	4.5	0.3	WD						5	4.3	0.1
Quadrula metanevra	23	20.5	1.4	1	33.3	0.1				24	20.9	0.4
Quadrula p. pustulosa	11	9.8	0.7							11	9.6	0.2
Quadrula quadrula	4	3.6	0.3							4	3.5	0.1
Truncilla truncata	1	0.9	0.1	WD						1	0.9	0.0
Total	112			3			0			115		
No. live species	10			3			0			10		
Total species	10			6			0			11		
CPUE (No./10min.)			7.0			0.2			0.0			1.9
Density (No./m^2)[2]	2.8			0.1			0.0			0.8		

[1]Distance from Kentucky bank

[2]Approximate density based on 50, 1x10m semi-quantitative samples along Transects 11 to 18

Table 3-4. Unionid relative abundance and community characteristics near Greenup Locks and Dam[1] (ORM 340.5 to 342.0), May 1999.

Species	No.[2]	%	Age (years)			Length (mm)			Weight (g)		
			Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Actinonaias ligamentina	WD										
Amblema p. plicata	142	11.5	8.7	3	16	73.7	25	113	136.0	8	335
Ellipsaria lineolata	84	6.8	6.5	3	15	55.4	14	88	60.9	12	226
Elliptio crassidens	WD										
Elliptio dilatata	1	0.1	11.0	11	11	96.0	96	96	102.0	102	102
Fusconaia ebena	1	0.1	5.0	5	5	38.0	38	38	32.0	32	32
Fusconaia flava	WD										
Lampsilis cardium	44	3.6	10.2	4	20	102.4	70	128	259.4	75	480
Lampsilis ovata	3	0.2	11.0	9	13	108.7	105	116	301.0	224	364
Lampsilis siliquoidea	1	0.1	6.0	6	6	90.0	90	90	110.0	110	110
Leptodea fragilis	WD										
Ligumia recta	45	3.7	7.4	4	12	124.4	79	154	184.9	56	362
Megalonaias nervosa	7	0.6	9.7	7	11	111.9	83	124	273.6	130	375
Obliquaria reflexa	426	34.6	6.1	3	12	42.4	24	57	37.5	2	84
Obovaria retusa	SF										
Plethobasus cyphyus	2	0.2	9.5	5	14	84.0	60	108	190.0	72	308
Pleurobema cordatum	3	0.2	12.7	12	14	68.3	58	74	148.7	110	192
Potamilus alatus	26	2.1	6.7	4	9	99.2	56	120	105.1	18	186
Quadrula metanevra	186	15.1	9.0	4	15	62.3	33	80	99.4	14	204
Quadrula nodulata	1	0.1	7.0	7	7	56.0	56	56	98.0	98	98
Quadrula p. pustulosa	194	15.8	8.7	3	15	46.5	23	68	56.3	12	100
Quadrula quadrula	63	5.1	9.5	3	16	63.4	28	79	90.4	6	150
Truncilla donaciformis	WD										
Truncilla truncata	1	0.1	3.0	3	3	25.0	25	25	5.0	5	5
Total	1,230		8.2	3	20	72.0	14	154	113.9	2	480
Live species	18										
Total species	24										
% ≤3 years			0.1								
% ≤5 years			7.6								

[1]Based on qualitative sampling along transects, free dives, and bank searches.
[2]Best condition reported; WD=weathered shell, SF=sub-fossil specimen.

4.0 Conclusions and Recommendations

Unionids have colonized the downstream reach of the study area, as a low density unionid community was found between Transects 11 and 18. This appears to be a newly colonizing bed. Although density appears to be low, species richness was high (18 species), recent recruitment is apparent, and maximum age was only 20 years old. No Federally endangered species were collected. However, Federally endangered species have been collected in other upper Ohio River beds (ESI, 1998a) with similar characteristics (low density, high species richness, and evidence of reproduction) and several species that are rare in the upper Ohio River and/or are protected by Kentucky and/or Ohio were found. Federally endangered species may be present, but in a very low frequency (<0.1% of the community).

This unionid bed will probably not be affected by this project since it is located at least 2,000m downstream of the lock. However, this bed should be considered in project planning.

The fact that such a diverse community inhabits the inside bend of this river reach suggests that the right descending bank may harbor an even better community, as is the case downstream of Belleville Locks and Dam (ESI, 1998a). Outside bends have more consistent flow, are less depositional than inside bends, and are often more conducive to unionid communities (ESI, 1997). Williams and Schuster (1989) found nine unionid species while brailing between ORM 342.0 and 343.5 along the Ohio bank eventhough their sampling method was fairly inefficient. The Ohio side of the river may harbor a higher density and species rich unionid community than the study area and future study in this river reach is warranted.

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APPENDIX C

BHE ENVIRONMENTAL, INC. - INDIANA BAT SURVEY

1086.01 21 May 1999

MIST NET SURVEY FOR THE INDIANA BAT ALONG THE PROPOSED GREENUP DAM EXPANSION IN GREENUP COUNTY, KENTUCKY

Submitted to:

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Section 1.0: Introduction

As part of the proposed Ohio River Main Stem System Study, the U.S. Army Corps of Engineers, Huntington District proposes to expand the Greenup Locks & Dam facility. The proposed expansion area covers approximately 160 acres along the Ohio River in Greenup County, Kentucky (Figure 1). The U.S. Fish and Wildlife Service (FWS) indicates the endangered Indiana bat (*Myotis sodalis*) may be present within the proposed project site. A preliminary site visit indicated potential roost habitat for Indiana bats occurs within the proposed project area (pers. comm. Ken Lammers). If Indiana bats are present, clearing trees within the proposed project area while the species occupies summer habitat (15 April–15 September) may affect Indiana bats.

BHE Environmental, Inc. (BHE) was retained to survey for the Indiana bat within the proposed project area. BHE conducted a mist net survey and determined habitat suitability for Indiana bats within the proposed project area.

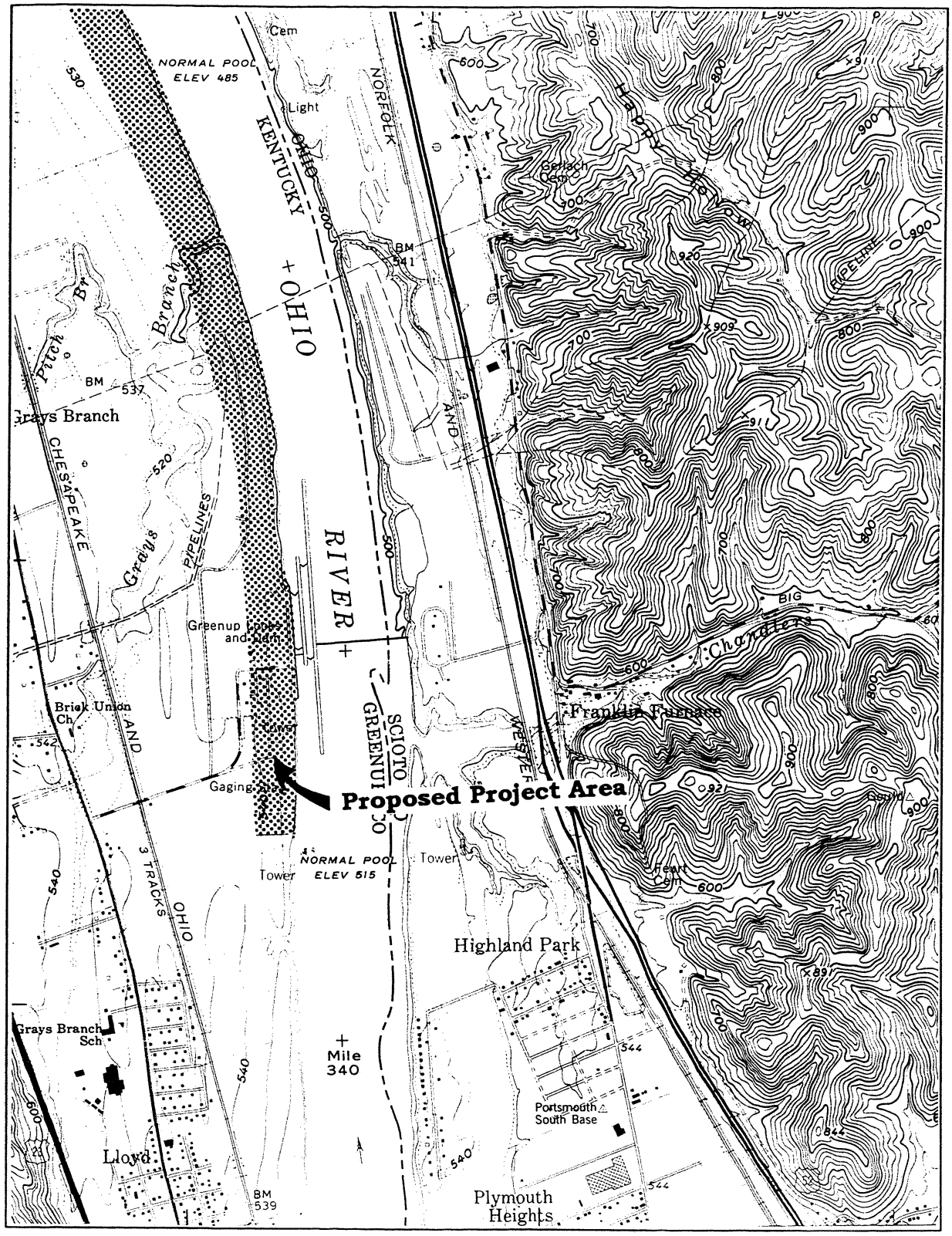

FIGURE 1. Location of proposed Greenup Locks & Dam Facility expansion area (Wheelersburg OH-KY quadrangle).

Section 2.0: Natural History of the Indiana Bat

The Indiana bat is found throughout the eastern United States, from Oklahoma, Iowa, and Wisconsin east to Vermont, and south to northwestern Florida (Barbour and Davis 1969). The species is migratory, and this range includes both summer and winter habitat. The winter range is associated with regions of karst topography, primarily Indiana, Kentucky, and Missouri. The majority of summer occurrences are primarily from the glaciated portions of the midwest U.S. (southern Iowa and Michigan; northern Missouri, Illinois, and Indiana; and western Ohio). However, data on summer distribution may reflect lack of search effort in some areas (FWS 1999). Summer occurrences of Indiana bats are known from 29 counties throughout Kentucky (Figure 2; FWS 1999).

In summer, Indiana bats migrate to forested bottomlands, uplands, and riparian habitats. This species roosts under exfoliating bark or in cavities of trees. Reproductive females form maternity colonies that may consist of up to 100 adult female bats (FWS 1999). Male Indiana bats tend to roost singly or in small groups (FWS 1999). Males may occur anywhere throughout the range of the species, including near hibernacula.

Indiana bats forage most frequently in upland and riparian forests, but they also may forage along wooded edges between forests and croplands, and over fallow fields (Brack 1983, LaVal and LaVal, 1980). They frequently use open space over streams as travel corridors.

Indiana bats were listed by the federal government as endangered on 11 March 1967. Populations across the species range (as recorded from counts in hibernacula) have declined since the late 1950s. A principle cause of decline is destruction of hibernacula from collapse, flooding, or vandalism by humans. Suspected contributing factors include loss of suitable summer habitat, and contamination by pesticides (FWS 1999).

Between 1960 and 1975, Indiana bat populations in Kentucky declined by an estimated 145,000 bats. During the past 15 years, populations in west-central, northeastern, and extreme southeastern Kentucky have declined, while populations in east-central and western parts of the state have increased (FWS 1999). The total known population of Indiana bats continues to decline (FWS 1999).

A recovery plan for Indiana bats was developed by a FWS-sponsored recovery team in 1983 (FWS 1983). The team currently is revising the plan to include updated information on Indiana bat ecology, and to highlight the continued and accelerated decline of the Indiana bat (FWS 1999). Briefly, objectives of the Indiana bat recovery plan include: (1) protect hibernacula, (2) maintain, protect, and restore summer maternity habitat, (3) monitor population trends through winter censusing, (4) educate the public, and (5) continue research. Maintenance, protection, and restoration of summer habitat (including maternity roost sites and foraging habitat) are now recovery priorities.

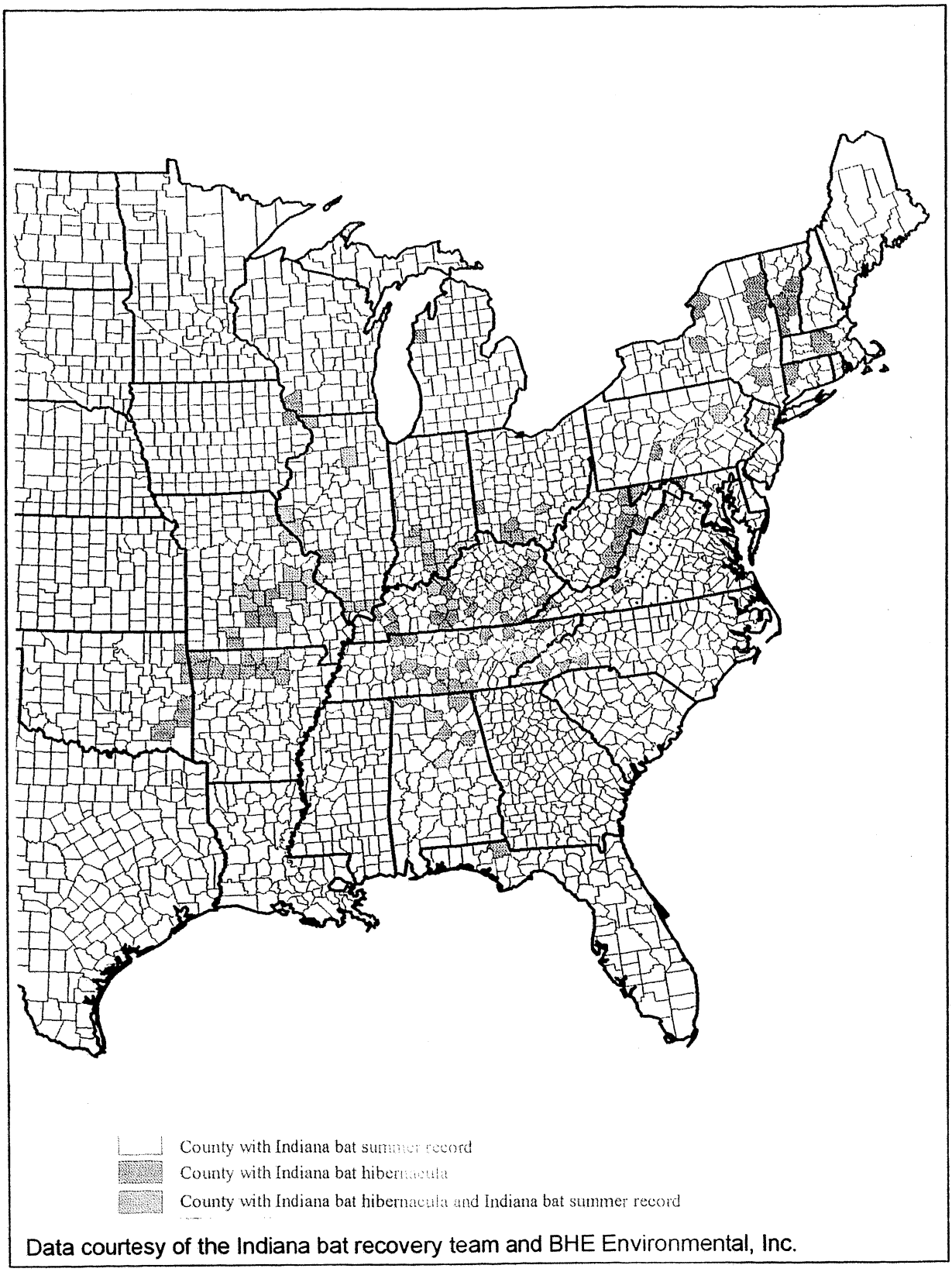

FIGURE 2. Range of the Indiana bat in the United States.

Section 3.0: Methods

3.1 BAT CAPTURE

During 15-16 May 1999, BHE conducted a mist net survey in the proposed project area (Figure 1). Based on habitat characteristics and coordination with the FWS, Cookeville Field Office (pers. comm., Jim Widlak), two mist net sites were established within proposed project boundaries (Figure 3; Appendix A). Mist net site selection was based upon extent of canopy cover, presence of an open flyway, and forest conditions near the site.

The mist net survey was conducted according to guidelines developed by the Indiana bat recovery team (March 1999). At each site, two mist nets were deployed for two nights, for a total of four net–nights per site (a net–night equals one net deployed for one night). During the survey, a total of 8 net–nights were completed.

Mist nets were constructed of black nylon or monofilament nets with 1.5–inch mesh and frames similar to those described by Gardner et al. (1989). Mist nets were placed along forest corridors likely provide an open flyway for bats. Nets were 20 feet tall and 30–45 feet wide, depending upon the width of the corridor. When possible, nets were bounded by vegetation above and on both sides to facilitate capturing bats.

Mist nets were deployed at dusk (2040–2115 h) and monitored every 20 minutes until at least 0200 h. Disturbance near nets between checks was minimized. Following capture, we recorded species, capture location, age, sex, reproductive condition, right forearm length, and weight for each bat.

Weather conditions were documented each night to confirm netting was conducted in accordance with mist netting guidelines. Each hour, we recorded air temperature, wind speed, cloud cover, precipitation, and visibility of the moon. A standard mercury thermometer was used to record temperature, and wind speed and percent cloud cover were estimated.

3.2 HABITAT ASSESSMENT

Habitat near mist net sites was characterized to determine potential suitability for bats. The following habitat characteristics were recorded at each mist net site:

- Species list of dominant canopy, understory, and herbaceous vegetation
- Estimate of the average forest canopy closure over nets
- Estimate of the average size of canopy, understory, and herbaceous stems
- Other conditions pertinent to the quality of Indiana bat habitat

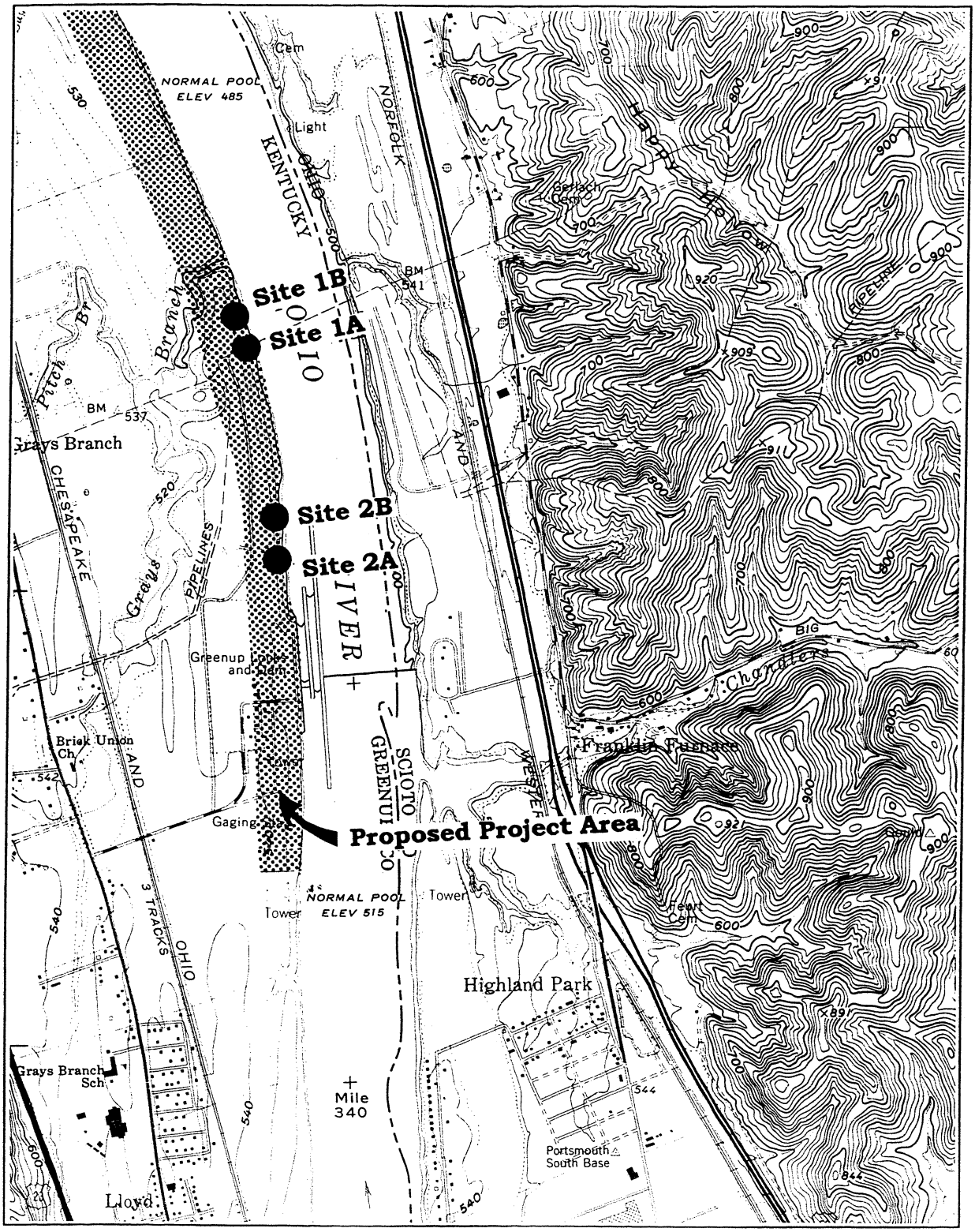

FIGURE 3. Location of mist net sites within the proposed project area (Wheelersburg OH-KY quadrangle.)

Section 4.0: Results

4.1 BAT CAPTURE

During 15-16 May 1999, 3 big brown bats (*Eptesicus fuscus*) were trapped within the proposed project area (Table 1). Two of the bats captured were pregnant females; one bat escaped before gender and reproductive condition was determined. No Indiana bats were captured during the survey. No federally- or state-listed species of bats were captured. Bats were captured at one (Site 1b) of four sites. No bats were captured at sites 1a, 2a, and 2b.

TABLE 1. Bats captured within the proposed Greenup Locks & Dam Facility expansion area during 15-16 May 1999.

Site No.	Date (1999)	Species	Common Name	Description
1b	15 May	*Eptesicus fuscus*	Big brown bat	Escaped
1b	16 May	*Eptesicus fuscus*	Big brown bat	Pregnant female
1b	16 May	*Eptesicus fuscus*	Big brown bat	Pregnant female

During mist net surveys, weather was mild and within guidelines of the Indiana bat recovery team. Air temperatures ranged from 51°F to 76°F. No precipitation occurred during the survey.

4.2 HABITAT ASSESSMENT

BHE documented habitat characteristics within the proposed project area (Table 2). Approximately half (80 acres) of the 160-acre area is forested. Non-forested portions include paved industrial areas, mowed pasture, and old field habitat (Appendix A). Human disturbance (e.g., mowing, roads, trails, past logging activity) is evident throughout the project area.

Forest within the project area consists primarily of trees with diameter at breast height (dbh) less than 10 inches. Near mist net sites 1a and 1b, 99 percent of trees are silver maple (*Acer saccharinum*), which form a relatively even-age stand. Silver maple and cottonwood (*Populus deltoides*) with dbh greater than 12 inches are scattered throughout the forested area. Overstory trees provide at least 85% canopy closure. Understory vegetation typically is dense, except on vehicle trails. Poison ivy vines cover many of the trees near mist net sites.

One perennial stream, Gray's Branch, flows through the project area. The stream is approximately 12-18 inches wide. Stream banks are up to 40-feet in height and are steeply sloped. The stream channel is partially blocked with debris and overhanging vegetation. Along the banks of Gray's Branch are large trees with dbh up to 4 feet.

TABLE 2. Characteristics of habitat near mist net sites.

	Mist Net Site 1	Mist Net Site 2
Dominant Canopy Trees	Silver maple (A few sycamore, black locust, tree of heaven, and black willow exist along the edges of the site).	Cottonwood Box elder Sycamore Black locust
Estimated Canopy Closure	90 %	85 %
Average Canopy DBH	10 inches	12 inches
Dominant Understory Trees	Silver maple American elm Hackberry	Box elder Black cherry American elm
Average Understory DBH	2 inches	2 inches
Dominant Herbaceous Plants	Poison ivy Multiflora rose Goldenrod Elderberry	Poison ivy Multiflora rose Honeysuckle

Section 5.0: Discussion

BHE conducted a mist net survey with the level of effort recommended by the FWS Cookeville Field Office and the Indiana Bat Recovery Team for assessing the presence/absence of Indiana bats. No Indiana bats were captured during the survey. Therefore, presence of Indiana bats within the project area was not confirmed.

The proposed project area appears to provide low to moderate quality habitat for Indiana bats. Within the forested area, trees primarily are less than 10 inches dbh with a limited number of larger trees. Suitable roosting habitat for Indiana bats appears to be limited although the large cottonwoods provide some potential roost sites. The silver maple trees have little exfoliating bark and generally do not provide potential roost sites for Indiana bats. Dense poison ivy vines growing on many of the trees may reduce potential for suitable roost sites for Indiana bats. Non-forested areas within the proposed project area do not provide suitable habitat for roosting Indiana bats.

This mist net survey did not confirm presence of Indiana bats within the proposed project area. However, survey results are not valid indefinitely. Changes in habitat characteristics may change habitat suitability for Indiana bats. The FWS may request additional Indiana bat surveys if forest within the project area is not cleared within 1–2 years.

Three big brown bats *(Eptesicus fuscus)* were captured within the proposed project area. This species is common throughout North America. It ranges throughout the United States from Alaska and Canada to Mexico and South America. Big brown bats do not migrate; there appears to be no difference in range from summer to winter (Barbour and Davis 1969). The big brown bat is found throughout Kentucky during all seasons (Barbour and Davis 1974). It is commonly found in buildings, but also is known to roost in rock crevices, expansion joints of bridges and dams, and hollow trees.

Section 6.0: Literature Cited

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Personal communication, Amy Henry (BHE Environmental, Inc.) with Jim Widlak (FWS Cookeville Field Office), 11 May 1999.

U.S. Fish and Wildlife Service (FWS). 1999. Agency draft Indiana bat (*Myotis sodalis*) revised recovery plan. Fort Snelling, Minnesota. 53 pp.

U.S. Fish and Wildlife Service (FWS). 1983. Recovery Plan for the Indiana Bat. 80 pp.

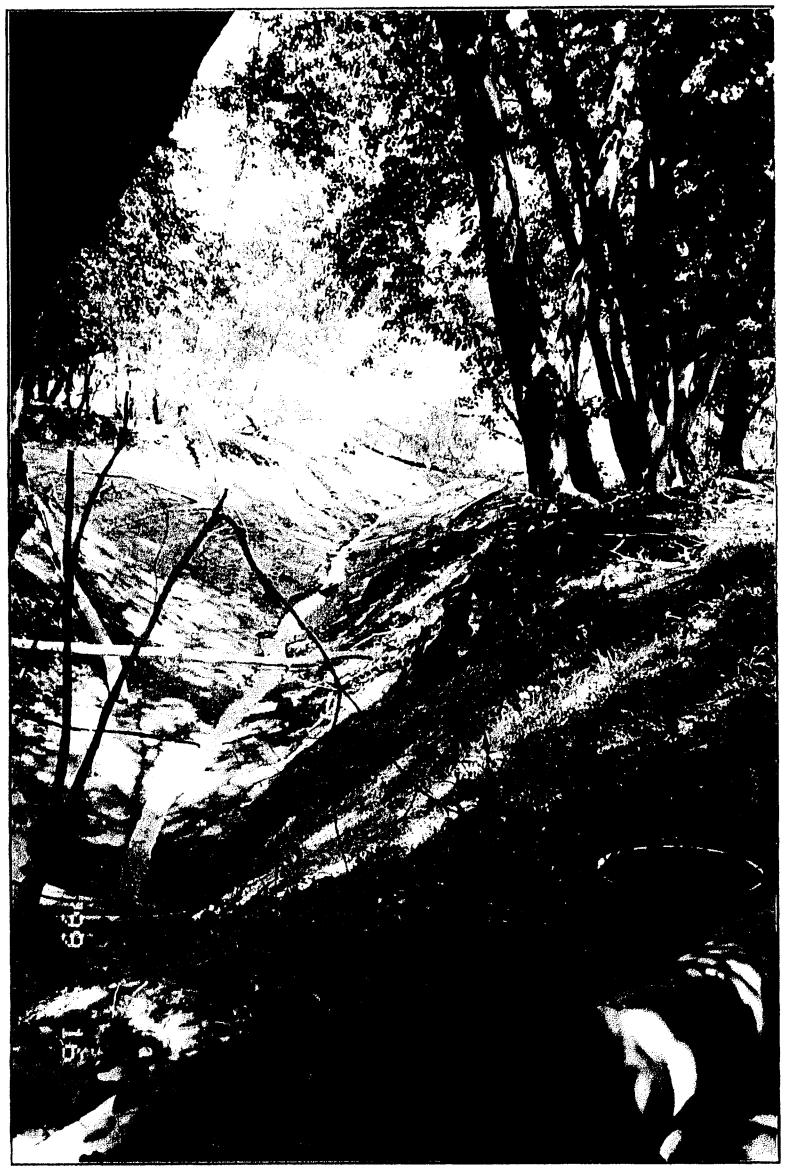
Appendix A
Photographs

Mist Net Site 1A

Mist Net Site 1B

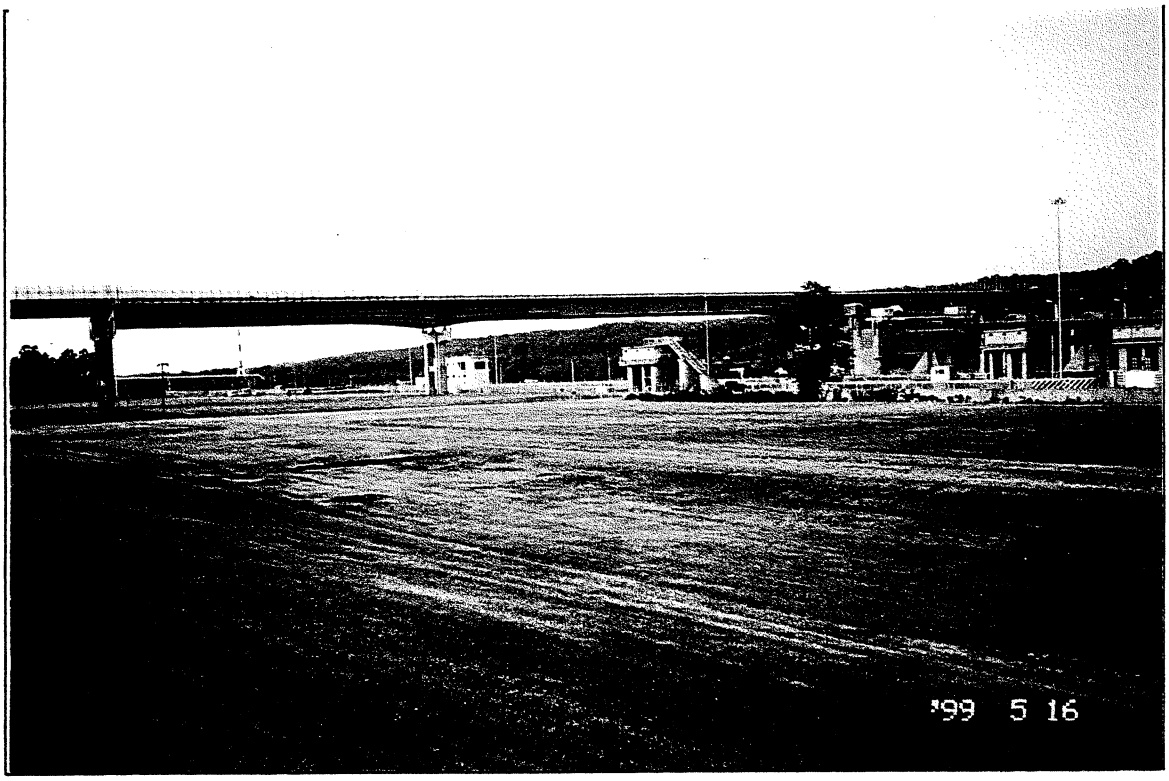
Mist Net Site 2A

Mist Net Site 2B

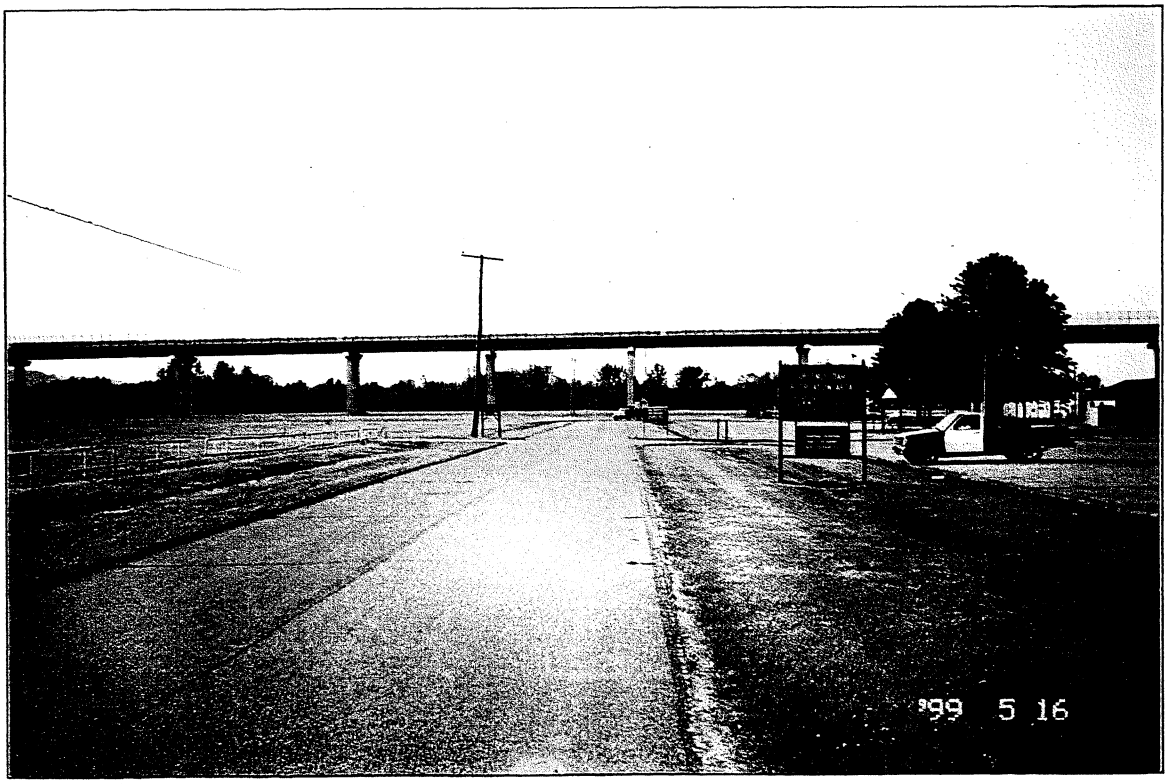


Gray's Branch, facing downstream

Gray's Branch, facing upstream



Greenup Locks and Dam



Greenup Dam Recreation Area

APPENDIX D

COE UNPUBLISHED REPORT - TERRESTRIAL INVENTORY FOR GREENUP LOCKS AND DAM

Terrestrial Habitat Description

Northern Scrub- On September 8, 1998 the northernmost extreme of Corps property was surveyed for terrestrial habitats and a species inventory was completed. Temperatures remained in the mid-70's ° F throughout the day with full sun and little wind. A typical fall day. Full precipitation and weather data is available from the National Weather Service for this region. The entire area surveyed measured little more than 1.5 acres and was a disturbed woodland. For ease of narrative description, the area was divided into two communities. The attached species inventory is for both communities.

A gravel driveway bisected the area running south to north. This roadway was an access drive for fisherman using the bank of the Ohio River for angling. The road terminated at the northern edge of this woodland, and Corps property.

The area west of this roadway was sparsely occupied by a 15-20 year old stand of trees and their constituents. The canopy was dominated by specimens of wild black cherry, *Prunus serotina* (20%), black locust, *Robina pseudo-acacia* (40%), silver maple, *Acer saccharinum* (5%) and American sycamore, *Platanus occidentalis* (5%). As given by the percent cover, much of the site remained open beneath these young trees. Though not well developed, an understory of American elm, *Ulmus americana*, and wild black cherry had generated under the open canopy. Disturbance and the sparsity of cover had allowed a dense herbaceous layer to form. The dominants formed nearly monotypic patches of poison ivy, *Toxicodendron radicans* (80%), deer tongue grass *Panicum clandestinum* (10%), and stinging nettle, *Urtica dioica* (5%). This woodland community was surrounded by natural gas transmission easements and mowed fields. The woodland was therefore fringed with sucessional assemblages of wingstem *Verbesina alternifolia*, blackberry *Rubus* spp., and staghorn sumac *Rhus typhina* in monotypic patches.

The area east of the roadway was dominated by 10-15 year old sycamore (30%), boxelder, *Acer negundo* (10%), and black locust (10%). This woodland community was also very open with a developing understory of boxelder (5%), black locust (5%) and wild black cherry (<5%). Silver maple were also prominent in the understory near the banks of the Ohio River. The herbaceous community profited from the loose canopy and created nearly impassable patches of wingstem (30%), Brachyelytrum, *Brachyelytrum erectum* (20%), giant goldenrod, *Solidago gigantea* (10%) and woodland sunflower *Helianthus divaricatus* (5%) monocultures. Virginia rye, *Elymus virginicus* and poison ivy were also in evidence throughout the community. The community was edged with hay fields on the north and south, a roadway on the west, and the Ohio River to the east. Thickets of woodland sunflower, wingstem, staghorn sumac, and pokeweed *Phytolacca americana* edged this community on all sides.

This site was generally, and in some locations steeply, sloping toward the Ohio River. The eastern half of the community was covered with large sandstone rip-rap to protect the banks from erosion. Below the rip-rap a mud-flat had developed along the banks of the Ohio River owing to sustained low water conditions. Blunt-spike rush, *Eleocharis obtusa* had created a carpet of lush vegetation that was being used by a killdeer *Charadrius vociferus,* the day of the survey. The habitat is no doubt extremely ephemeral and the only terrestrial habitat used during this survey by vertebrate wildlife. Otherwise the area provided little in the way of quality terrestrial habitats and no aquatic or wetland habitats. An abandoned trash dump along the access road provided the only apparent denning opportunities in this otherwise droughty, uniform landscape. Occasional fallen logs may provide additional sites for small mammals and herptiles. However, the bunchy vegetative monocultures that dominate these very open woods do not seem to lend themselves to diverse vertebrate communities. No vertebrate use was observed by sight or sign during the survey (excepting 1 killdeer). Adjacent hay fields showed evidence of large mammal traffic, probably deer. No scat or former rubs were observed.

Species Observed: Sept. 8, 1998

Birds

Charadrius vociferus	Killdeer

Herbaceous Plants

Agrostis alba	redtop
Ambrosia artemisifolia	common ragweed
Amphicarpa bracteata	hog peanut
Asclepias syriaca	milkweed
Aster spp.	aster
Bidens ceruna	nodding bur marigold
Boehmeria cylindrica	false nettle
Brachyelytrum erectum	
Campsis radicans	trumpet vine
Cassia fasciculata	wild sensitive plant
Chenopodium album	lamb's quarter
Cyperus strigosus	galingale
Daucus carota	Queen Anne's lace
Desmodium spp.	sticktight
Digitaria ischaemum	smooth crabgrass
Eleocharis obtusa	blunt spikerush
Eleusine indica	goose grass
Elymus virginicus	Virginia wild rye
Eupatorium fistulosum	common Joe-pye weed
Eupatorium rugosum	white snakeroot
Geum canadense	white avens
Gnaphalium obtusifolium	cudweed
Helianthus divaricatus	woodland sunflower
Helianthus tuberosus	Jerusalem artichoke
Ipomoea lacunosa	small-flowered morning glory
Lactuca biennis	blue lettuce
Lactuca canadensis	horseweed
Leersia oryzoides	rice cutgrass
Lespedeza cuneata	lespedeza
Medicago sativa	alfalfa
Menispermum canadense	moonseed
Mimulus ringens	common monkey-flower
Panicum clandestinum	deertongue grass
Phytolacca americana	pokeweed
Polygonum pensylvanicum	pennsylvania smartweed
Polygonum scandens	wild buckwheat
Rosa multiflora	multiflora rose
Rubus occidentalis	black rasberry
Rubus spp.	blackberry
Setaria faberii	
Setaria glauca	yellow foxtail
Setaria viridis	green foxtail
Setaria viridis	green foxtail
Solidago gigantea	giant goldenrod
Sorghum halepense	johnsongrass
Urtica dioica	stinging nettle
Verbesina alternifolia	wingstem
Veronica serpyllifolia	thyme-leaved speedwell

Woody Plants

Acer negundo	boxelder
Acer saccharinum	silver maple
Ailanthus altissima	tree-of-heaven
Amorpha fruticosa	false indigo
Carya cordiformis	bitternut hickory
Carya laciniosa	shellbark hickory
Julgans nigra	black walnut
Morus alba	white mulberry
Platanus occidentalis	American sycamore
Populus deltoides	cottonwood
Prunus serotina	wild black cherry
Quercus muehlenbergii	chinquapin oak
Quercus velutina	black oak
Rhus typhina	staghorn sumac
Robinia pseudo-acacia	black locust
Toxicodendron radicans	poison ivy
Ulmus americana	American elm

	cattail
Uniola latifolia	
Verbascum thapsus	mullein
Verbena urticifolia	white vervain
Verbesina alternifolia	wingstem
Vernonia gigantea	ironweed

Woody Plants

Acer negundo	boxelder
Acer saccharinum	silver maple
Amorpha fruticosa	false indigo
Cephalanthus occidentalis	buttonbush
Fraxinus pennsylvanica	green ash
Platanus occidentalis	American sycamore
Populus deltoides	cottonwood
Prunus serotina	wild black cherry
Rhus glabra	smooth sumac
Rhus typhina	staghorn sumac
Robinia pseudo-acacia	black locust
Salix nigra	black willow
Toxicodendron radicans	poison ivy
Ulmus americana	American elm
Vitis vulpina	winter grape

Terrestrial Habitat Description

Open Fields- On September 15 & 17, 1998 the open fields within Corps property were surveyed for terrestrial habitats and a species inventory was completed. Temperatures remained in the low-90's ° F on the 15th and the mid-80's ° F on the 17th and little wind. Full precipitation and weather data is available from the National Weather Service for this region. Much of the area of the Corps lands at Greenup Locks & Dam were composed of open fields that were mowed frequently enough to maintain various herbaceous successional stages. The area surveyed covered the majority of Corps property and measured more than ??? acres. Included in this habitat type are successional fields following a natural gas transmission line within Corps property, and maintained fields around the lock & dam maintenance facility. The area, though all open herbaceous communities, varied in it's successional status. For ease of narrative description, the area was loosely divided into three communities. The attached species inventory is for the entire area.

Gasline right-of-way between the access road and the banks of the Ohio formed a consistent herbaceous community approximately 150 feet wide and 200+ feet long. This habitat is bordered by immature woodlands on the north and south, the Ohio River on the east, and a gravel access road on the west. The site was a disturbed sand and gravel soil. Gasline placement among other disturbances had left an undulating land surface that gently sloped toward the Ohio River. The actual bank of the river was rip-rapped with medium sandstone boulders. The vegetative community was in a late stage of herbaceous succession. Dominants included giant goldenrod(%), johnsongrass(%) and lespedeza(%). Black locust, sumac and false indigo, *Amorpha fruticosa* occurred sparsely in this herbaceous stand. The community was edged with sumac thickets.

Gasline right-of-way west and north of the access formed an "L" shaped community with the long axis oriented along a north-south trajectory. This community is distinguished by its lack of topographic relief and its mid-successional vegetative status. Further, the dominance of johnsongrass and lespedeza gives way to large monotypic patches of switchgrass, *Panicum virgatum*(%). Codominants included giant goldenrod (%). The thick stands of switchgrass may indicate a different management regime from the area near the Ohio River. Whatever the case, this clump-forming grass would provide thick nesting and escape cover for small mammals and avifauna. No encounters were recorded during the September surveys.

Blackberry and smooth sumac, *Rhus glabra* formed thickets along the edge of this linear openland, 200-300 feet wide. The transmission line traveled west away from the Ohio River before it met a north-south running trunkline. This transmission facility opened a slightly broader corridor in the surrounding woodlands. The vegetative community, however, remained essentially unchanged along much of the trunkline. Near the southern terminus of this main trunkline on Corps property the land surface became more undulating with a return of lespedeza(%), wingstem(%), sticktights(%), and deertongue grass(%). Giant goldenrod (%) remained among the dominants of this late successional community. Switchgrass became rather sparse in this small stretch of open land. Grease grass, Triodia flava, New England aster, Aster novea-angliae, and heath aster, Aster pilosus were among the conspicuous minority of the site. This community was largely impassable due to this thick, somewhat diverse herbaceous community.

Near the southern terminus of the Gas Transmission right-of-way on Corps lands, a gasline transmission maintenance facility was located along the access road near a sharp eastward bend in the road. This facility was graveled, with a large section of the transmission line above the surface of the ground for access. A potential jurisdiction wetland habitat was identified along the eastern edge of successional habitats near this facility, north of the access road (see Figure 1). This depressional habitat occurred 150-200 feet north of the road and was no more that 0.1 acre in arial extent. Dominants included rice cut-grass, *Leersia oryzoides*(%), boneset, *Eupatorium perfoliatum*(%), and narrowleaf cat-tail, *Typha angustifolia*(%). Water plantain, *Allisma subcordatum* and arrowleaf, *Sagittaria latifolia*. were minority constituents restricted to tire ruts in the center of the depression. Hydrology was confirmed in clear wetland drainage patterns and desiccated vegetation. Soils were not determined.

Species Observed: Sept. 15, 1998 (Open fields)

Herbaceous Plants

Achillea millefolium yarrow
Agrostis alba redtop
Allisma subcordatum common water plantain
Ambrosia artemisifolia common ragweed
Ambrosia trifida giant ragweed
Andropogon virginicus broom-sedge
Apcynum cannabinum indian hemp
Asclepias syriaca milkweed
Aster novae-angliae New England aster
Aster pilosus heath aster
Bidens ceruna nodding bur marigold
Bidens coronata tickseed sunflower
Bidens frondosa beggar's tick
Boehmeria cylindrica false nettle
Campsis radicans trumpet vine
Carex frankii sedge
Cassia fasciculata wild sensitive plant
Cichorium intybus chicory
Cirsium vulgare thistle
Cirsium arvense Canada thistle
Clematis virginiana virgin's bower
Conium maculatum poison hemlock
Convolvulus arvensis field bindweed
Convolvulus sepium hedge bindweed
Coronilla varia crown vetch
Cyperus strigosus galingale
Dactylis glomerata orchardgrass
Daucus carota Queen Anne's lace
Desmodium perplexum sticktight
Digitaria ischaemum smooth crabgrass
Diodia teres buttonweed
Echinocloa crusgalli barnyard grass
Eleusine indica goose grass
Elymus virginicus Virginia wild rye
Eupatorium aromaticum small white snakeroot
Eupatorium coelestinum mistflower
Eupatorium fistulosum common Joe-pye-weed
Eupatorium perfoliatum boneset
Euphorbia maculata spotted spurge
Festuca pratensis meadow fescue
Gnaphalium obtusifolium cudweed
Helianthus tuberosus Jerusalem artichoke
Hibiscus moscheutos swamp rose-mallow
Impatiens capensis spotted jewelweed
Ipomoea lacunosa small-flowered morning glory
Lactuca biennis blue lettuce
Lactuca canadensis horseweed
Leersia oryzoides rice-cutgrass
Lespedeza cuneata lespedeza
Lobelia siphilitica great blue lobelia
Lonicera japonica Japanese honeysuckle
Lycopus americanus water horehound
Medicago sativa alfalfa
Melilotus officinalis yellow sweetclover
Menispermum canadense moonseed
Muhlenbergia schreberi nimblewill
Oenothera biennis evening primrose
Panicum agrostoides redtop panic-grass
Panicum clandestinum deertongue grass
Panicum virgatum switchgrass
Pastinaca sativa parsnip
Phleum pratense timothy
Phytolacca americana pokeweed
Plantago lanceolata English plantain
Plantago rugelii common plantain
Polygonum pensylvanicum pennsylvania smartweed
Polygonum scandens wild buckwheat
Rosa multiflora multiflora rose
Rubus occidentalis black rasberry
Rubus spp. blackberry
Sagittaria latifolia duck potato
Sambucus canadensis common elderberry
Saponaria officinalis soapwort
Scirpus validus soft-stem bulrush
Scutellaria lateriflora mad-dog skullcap
Setaria faberii
Setaria viridis green foxtail
Solanum carolinense horse nettle
Solidago gigantea giant goldenrod
Sorghum halepense johnsongrass
Spartina pectinata prairie cordgrass
Strophostyle helvola trailing wild bean
Tragopogon pratensis yellow goatsbeard
Trifolium pratense red clover
Triodia flava grease grass
Typha angustifolia narrow-leaved

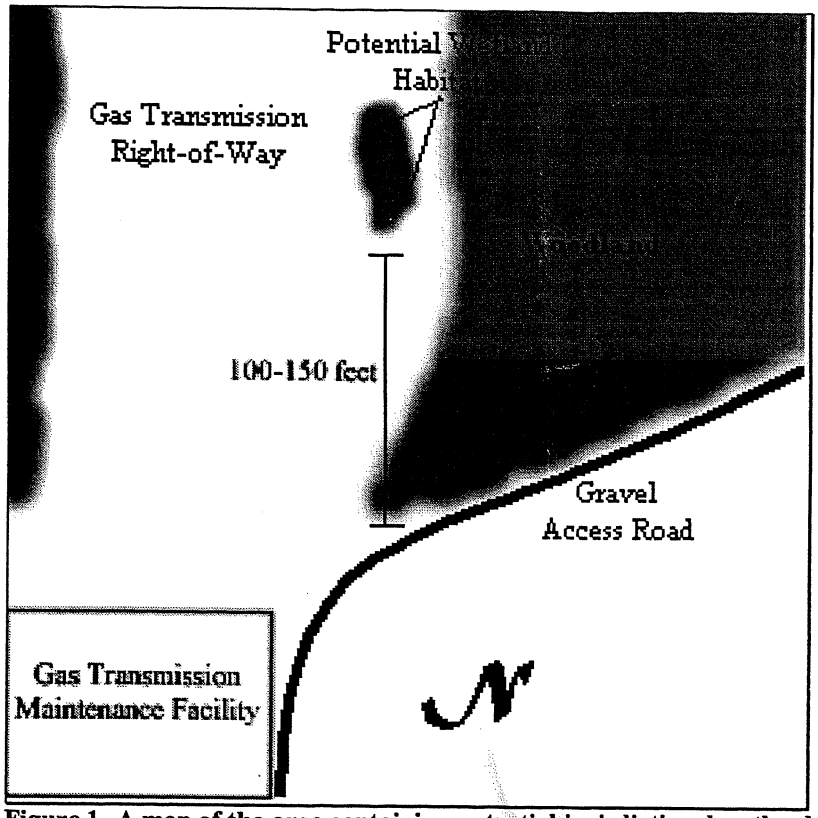


Figure 1- A map of the area containing potential jurisdictional wetlands near the gas transmission maintenance facility, Greenup Locks & Dam.

Open fields surrounding the Lock & Dam maintenance facility were disposed above the surrounding floodplains on a broad flat plateau of spoil material. This site was dominated by pasture varieties including meadow fescue, *Festuca pratense* (%), red clover, (%), and orchardgrass, *Dactylis glomera* (%). During these fall surveys, warm season varieties were apparent including grease grass, ironweed, and tickseeds. The site was maintained with regular mowing. The only vegetative variety on the site was offered by patches of annual grasses (*Setaria* spp.) and rutted areas harboring nodding bur marigold.

APPENDIX E

ORSANCO INFORMATION - AQUATIC SAMPLING ON OHIO RIVER

Fish Population Studies

Objective:

Characterize the diversity and distribution of fish in the Ohio River.

Program Description:

Fish population studies have been a major component of ORSANCO monitoring activities for almost 20 years. From 1975 until 1992, lockchamber studies were conducted in cooperation with state and federal environmental and fisheries agencies. Beginning in 1990, electrofishing was added in order to expand the types of habitats which could be studied. In 1993, lockchamber studies were suspended in order to devote more resources to data assessment. Electrofishing has now become the primary means utilized by the Commission to study fish populations in the Ohio River.

The focus of the electrofishing effort in recent years has been towards the collection of adequate data for development of biological criteria. In FY96, the emphasis was on additional development of the electrofishing method in order to allow a better understanding of the results. In FY97, the Commission will resume pool-specific population studies. One pool in the upper river (Hannibal) and one pool in the lower river (Smithland) will be studied. It is the intent of the Commission to conduct intensive surveys of each navigation pool of the river in order to better understand the geographic variation in fish assemblages.

Contact: Erich Emery, emery@orsanco.org, Aquatic Biologist

[ORSANCO Home Page]- [Biological Programs]

Macroinvertebrate Sampling

Objective:

Characterize benthic macroinvertebrate populations at fixed stations in the Ohio River.

Program Description:

Macroinvertebrate populations provide additional perspective on aquatic life conditions in the river. Because many species are highly sensitive to pollution, and because they are relatively immobile, the assessment of macroinvertebrate populations can bring valuable insights on water quality. The Commission has conducted macroinvertebrate sampling each year since 1990. To date, resource limitations have precluded extensive analysis of the results.

During the summer of 1997, ORSANCO expanded its macroinvertebrate sampling efforts. With funding provided by USEPA and guidance from a panel of macroinvertebrate experts, ORSANCO set forth to expand its macroinvertebrate program.

Concern has been expressed that continued proliferation of zebra mussels in the Ohio River could preclude the use of artificial substrates as a means of collecting macroinvertebrate samples. ORSANCO field crews encountered some problems with zebra mussel infestation of samplers in FY96. Should the situation worsen, alternative approached will have to be pursued. Barring any such difficulties, collection of macroinvertebrate samples will continue in FY97. Sampling locations utilized for fish population studies will also be used for macroinvertebrates. Analysis of the samples will be performed by a contractor.

[ORSANCO Home Page]- [Biological Programs]

Pool_Lock	Order	Family	Subfamily	Genus
GREENUP	AMPHIPODA	GAMMARIDAE		GAMMARUS
GREENUP	AMPHIPODA	GAMMARIDAE		GAMMARUS
GREENUP	AMPHIPODA	GAMMARIDAE		GAMMARUS
GREENUP	BASOMMATOPHORA	ANCYLIDAE		FERRISSIA
GREENUP	BASOMMATOPHORA	PHYSIDAE		PHYSELLA
GREENUP	BASOMMATOPHORA	PLANORBIDAE		MENETUS
GREENUP	BIVALVIA			
GREENUP	CLADOCERA	SIDIDAE		SIDA
GREENUP	COLEOPTERA			
GREENUP	COLEOPTERA	DRYOPIDAE		HELICHUS
GREENUP	COLEOPTERA	DRYOPIDAE		HELICHUS
GREENUP	COLEOPTERA	ELMIDAE		DUBIRAPHIA
GREENUP	COLEOPTERA	ELMIDAE		MACRONYCHUS
GREENUP	COLEOPTERA	ELMIDAE		STENELMIS
GREENUP	COLEOPTERA	ELMIDAE		STENELMIS
GREENUP	DIPTERA	CHIRONOMIDAE		
GREENUP	DIPTERA	CHIRONOMIDAE		ABLABESMYIA
GREENUP	DIPTERA	CHIRONOMIDAE		CHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE		CRYPTOCHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE		DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE		DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE		GLYPTOTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE		MICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE		NANOCLADIUS
GREENUP	DIPTERA	CHIRONOMIDAE		PARACHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE		PARAKIEFFERIELLA
GREENUP	DIPTERA	CHIRONOMIDAE		PHAENOPSECTRA
GREENUP	DIPTERA	CHIRONOMIDAE		POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE		POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE		POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE		POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE		PSEUDOCHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE		STENOCHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE		TANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE		TRIBELOS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	CLADOTANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	DICROTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	GLYPTOTENDIPES
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	PARACHIRONOMUS

GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	PARACHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	PHAENOPSECTRA
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	POLYPEDILUM
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	PSEUDOCHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	RHEOTANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	RHEOTANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	STENOCHIRONOMUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	TANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	TANYTARSUS
GREENUP	DIPTERA	CHIRONOMIDAE	CHIRONOMINAE	TRIBELOS
GREENUP	DIPTERA	CHIRONOMIDAE	ORTHOCLADIINAE	CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE	ORTHOCLADIINAE	CRICOTOPUS
GREENUP	DIPTERA	CHIRONOMIDAE	ORTHOCLADIINAE	NANOCLADIUS
GREENUP	DIPTERA	CHIRONOMIDAE	ORTHOCLADINAE	
GREENUP	DIPTERA	CHIRONOMIDAE	TANYPODINAE	
GREENUP	DIPTERA	CHIRONOMIDAE	TANYPODINAE	ABLABESMYIA
GREENUP	DIPTERA	CHIRONOMIDAE	TANYPODINAE	ABLABESMYIA
GREENUP	DIPTERA	CHIRONOMIDAE	TANYPODINAE	ABLABESMYIA
GREENUP	DIPTERA	CHIRONOMIDAE	TANYPODINAE	COELOTANYPUS
GREENUP	DIPTERA	CHIRONOMIDAE	TANYTARSINI	
GREENUP	DIPTERA	EMPIDIDAE		HEMERODROMIA
GREENUP	EPHEMEROPTERA	BAETIDAE		BAETIS
GREENUP	EPHEMEROPTERA	CAENIDAE		CAENIS
GREENUP	EPHEMEROPTERA	CAENIDAE		CAENIS
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENACRON
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENACRON
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENACRON
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENONEMA
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENONEMA
GREENUP	EPHEMEROPTERA	HEPTAGENIIDAE		STENONEMA
GREENUP	EPHEMEROPTERA	TRICORYTHIDAE		TRICORYTHODES
GREENUP	HAPLOTAXIDA	NAIDIDAE		
GREENUP	HAPLOTAXIDA	NAIDIDAE		DERO
GREENUP	HAPLOTAXIDA	NAIDIDAE		NAIS
GREENUP	HAPLOTAXIDA	NAIDIDAE		NAIS
GREENUP	HAPLOTAXIDA	NAIDIDAE		NAIS
GREENUP	HAPLOTAXIDA	TUBIFICIDAE		
GREENUP	HIRUDINEA			
GREENUP	HIRUDINEA	PISCICOLIDAE		MYZOBDELLA
GREENUP	HYDROIDA	CLAVIDAE		CORDYLOPHORA
GREENUP	HYDROIDA	HYDRIDAE		HYDRA
GREENUP	LYMNOPHILA	ANCYLIDAE		
GREENUP	LYMNOPHILA	PHYSIDAE		
GREENUP	LYMNOPHILA	PHYSIDAE		PHYSA

GREENUP	LYMNOPHILA	PLANORBIDAE		MENETUS
GREENUP	MEGALOPTERA	SIALIDAE		SIALIS
GREENUP	MESOGASTROPODA	HYDROBIIDAE		
GREENUP	MESOGASTROPODA	HYDROBIIDAE		SOMATOGYRUS
GREENUP	MESOGASTROPODA	PLEUROCERIDAE		ELIMIA
GREENUP	MESOGASTROPODA	PLEUROCERIDAE		LITHASIA
GREENUP	MESOGASTROPODA	PLEUROCERIDAE		PLEUROCERA
GREENUP	NEMATODA			
GREENUP	NEMATODA	MERMITHIDAE		
GREENUP	NEUROPTERA	SISYRIDAE		CLIMACIA
GREENUP	ODONATA	COENAGRIONIDAE		
GREENUP	ODONATA	COENAGRIONIDAE		ARGIA
GREENUP	ODONATA	COENAGRIONIDAE		ARGIA
GREENUP	ODONATA	COENAGRIONIDAE		ENALLAGMA
GREENUP	ODONATA	CORDULIDAE		NEUROCORDULIA
GREENUP	ODONATA	CORDULIIDAE		NEUROCORDULIA
GREENUP	ODONATA	CORDULIIDAE		NEUROCORDULIA
GREENUP	ODONATA	MACROMIIDAE		MACROMIA
GREENUP	OLIGOCHAETA			
GREENUP	TRICHOPTERA			
GREENUP	TRICHOPTERA	BRACHYCENTRIDAE		MICRASEMA
GREENUP	TRICHOPTERA	HYDROPSYCHIDAE		
GREENUP	TRICHOPTERA	HYDROPSYCHIDAE		CHEUMATOPSYCHE
GREENUP	TRICHOPTERA	HYDROPSYCHIDAE		HYDROPSYCHE
GREENUP	TRICHOPTERA	HYDROPTILIDAE		
GREENUP	TRICHOPTERA	HYDROPTILIDAE		HYDROPTILA
GREENUP	TRICHOPTERA	HYDROPTILIDAE		OXYETHIRA
GREENUP	TRICHOPTERA	LEPTOCERIDAE		NECTOPSYCHE
GREENUP	TRICHOPTERA	LEPTOCERIDAE		NECTOPSYCHE
GREENUP	TRICHOPTERA	POLYCENTROPODIDAE		
GREENUP	TRICHOPTERA	POLYCENTROPODIDAE		CYRNELLUS
GREENUP	TRICHOPTERA	POLYCENTROPODIDAE		CYRNELLUS
GREENUP	TRICHOPTERA	POLYCENTROPODIDAE		NEURECLIPSIS
GREENUP	TRICLADIDA			
GREENUP	TRICLADIDA	PLANARIIDAE		DUGESIA
GREENUP	TUBIFICIDA	TUBIFICIDAE		
GREENUP	VENEROIDA	CORBICULIDAE		CORBICULA
GREENUP	VENEROIDA	DREISSENIIDAE		DREISSENA

Species
FASCIATUS
FASICATUS
SP.
RIVULARIS
SP.
DILATATUS
SP.
CRYSTALLINA
SP.
LITHOPHILUS
SP.
SP.
GLABRATUS
HUMEROSA-SINUATA GR.
SP.
SP.
MALLOCHI
SP.
BICINCTUS
SP.
SYLVESTRIS
TREMULUS
VIERRIENSIS
SP.
NEOMODESTUS
NERVOSUS
SP.
SP.
DISTINCTUS
SP.
BATHOPHILA
SP.
HALTERALE
ILLINOENSE
ILLINOENSE GR.
SCALAENUM
SP.
SP.
SP.
FUSCICORNE
SP.
MANCUS GR.
LUCIFER
NEOMODESTUS
NERVOSUS
SP.
SP.
ABORTIVUS

SP.
SP.
CONVICTUM
HALTERALE
ILLINOENSE
SCALAENUM
SP.
SP.
EXIGUUS GR.
SP.
SP.
GUERLUS GR.
SP.
FUSCICORNE
BICINCTUS GR.
SP.
SP.
SP.
SP.
JANTA
MALLOCHI
SP.
SP.
SP.
SP.
SP.
AMICA
SP.
SP.
GILDERSLEEVEI
INTERPUNCTATUM
SP.
INTEGRUM
SP.
TERMINATUM
SP.
SP.
SP.
COMMUNIS
PARDALIS
SP.
SP.
SP.
LUGUBRIS
LACUSTRIS
SP.
SP.
SP.
SP.

DILATATUS
SP.
SP.
SP.
SP.
OBOVATA
SP.
SP.
SP.
SP.
SP.
SP.
TIBIALIS
SP.
OBSOLETA
MOLESTA
OBSOLETA
SP.
SP.
SP.
SP.
SP.
SP.
SP.
SP.
SP.
SP.
CANDIDA
SP.
SP.
FRATERNUS
SP.
SP.
SP.
TIGRINA
SP.
FLUMINEA
POLYMORPHA

APPENDIX F

TERRESTRIAL/AQUATIC HABITAT PHOTOGRAPHS

LIST OF PHOTOGRAPHS

AQUATIC AND TERRESTRIAL INVENTORY
GREENUP LOCKS AND DAM
HABITAT PHOTOGRAPHS
MAY 1999

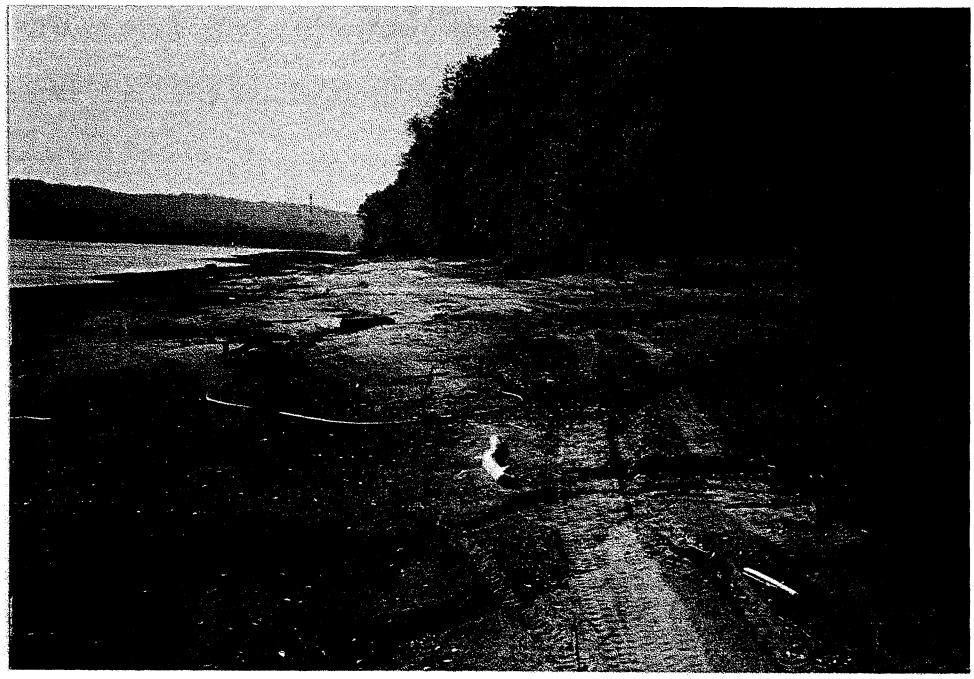
1	Overview of open field habitat looking north.
2	Close up of open field habitat looking west.
3	Overview of southern portion of riparian forest habitat looking south. Note relatively young cover types.
4	Overview of northern portion of riparian forest habitat. Note more mature plant growth.
5	Overview of riverbank habitat looking south.
6	Close up of riverbank habitat. Note predominance of willow and pioneer species.
7	Overview of upstream riverine habitat looking north.
8	Overview of upstream riverine habitat looking south. Note extensive overhanging vegetation/woody debris along shoreline.
9	Overview of downstream riverine habitat looking north.
10	Overview of downstream riverine habitat in vicinity of pipeline crossing.
11	Overview of backwater habitat located south of dam. Note extensive shoreline vegetation at northern extent.
12	Overview of backwater habitat located north of dam looking south.

Photograph 1: Overview of open field habitat looking north.

Photograph 2: Close up of open field habitat looking west.

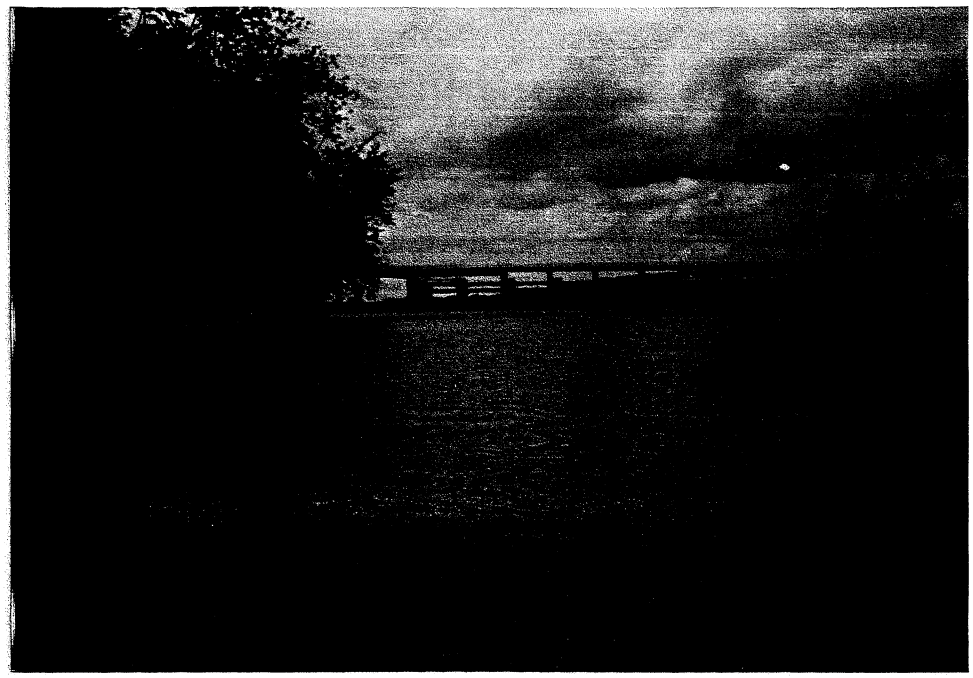
Photograph 3: **Overview of southern portion of riparian forest habitat looking south. Note relatively young cover types.**

Photograph 4: **Overview of northern portion of riparian forest habitat. Note more mature plant growth.**



Photograph 5: **Overview of riverbank habitat looking south.**

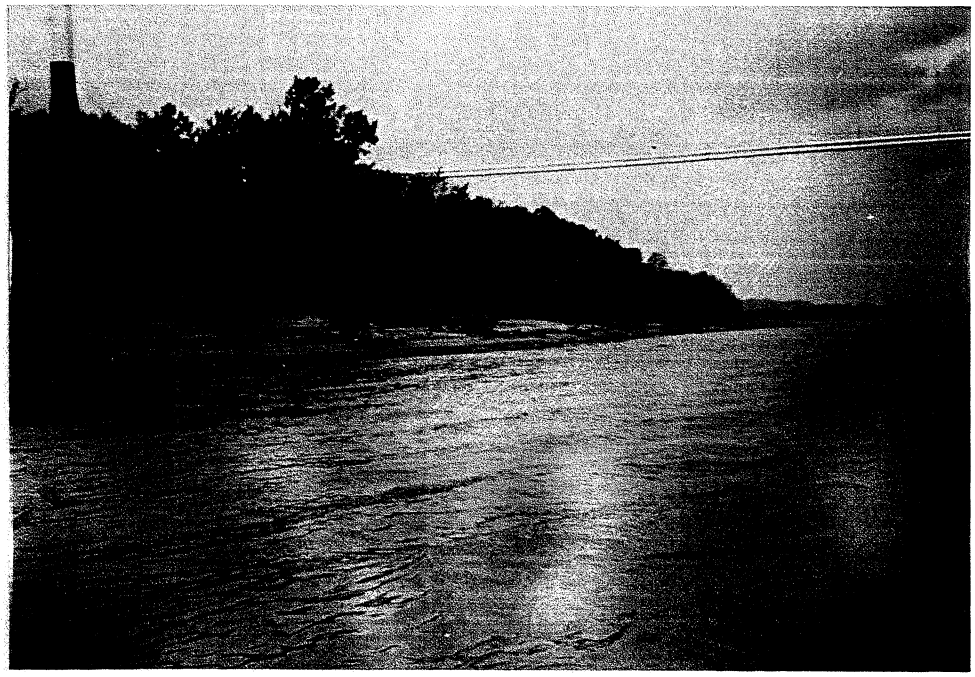
Photograph 6: **Close up of riverbank habitat. Note predominance of willow and pioneer species.**



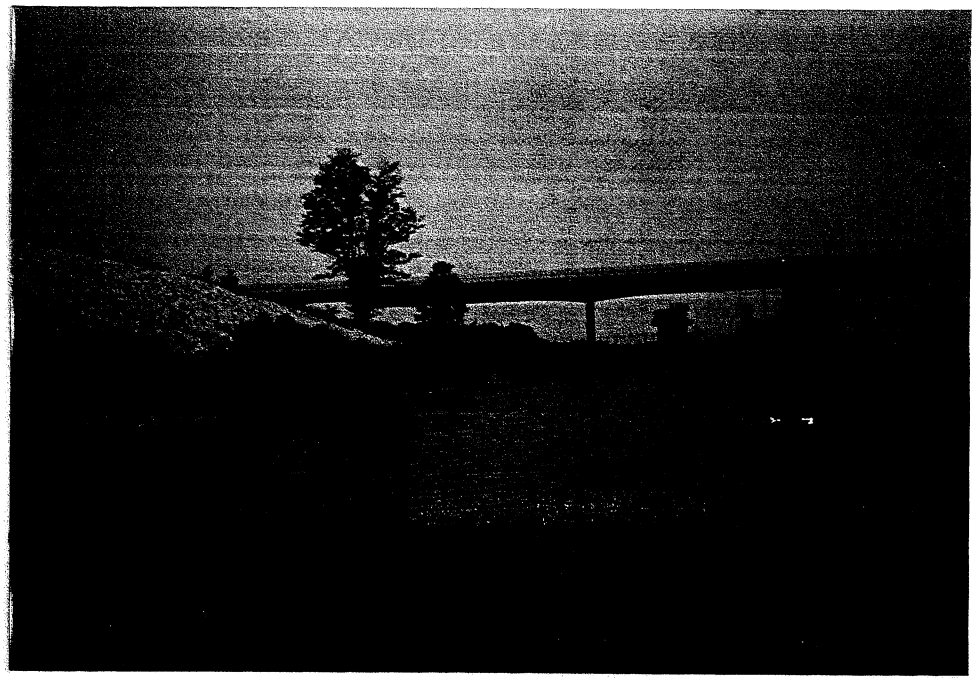
Photograph 7: **Overview of upstream riverine habitat looking north.**

Photograph 8: **Overview of upstream riverine habitat looking south. Note extensive overhanging vegetation/woody debris along shoreline.**

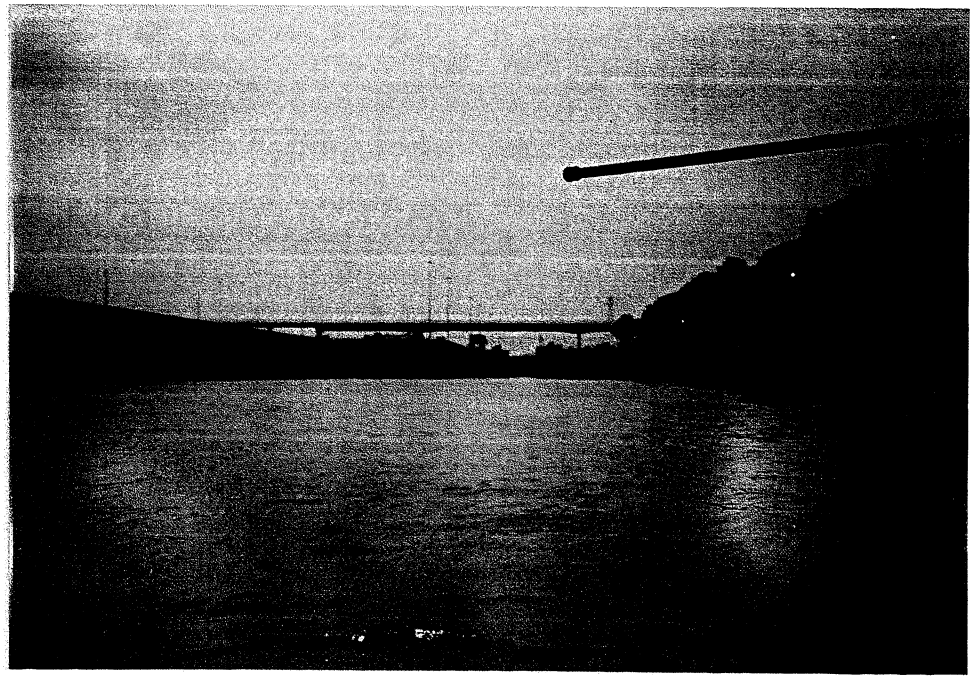
Photograph 9: Overview of downstream riverine habitat looking north.



Photograph 10: Overview of downstream riverine habitat in vicinity of pipeline crossing.



Photograph 11: **Overview of backwater habitat located south of dam. Note extensive shoreline vegetation at northern extent.**



Photograph 12: **Overview of backwater habitat located north of dam looking south.**

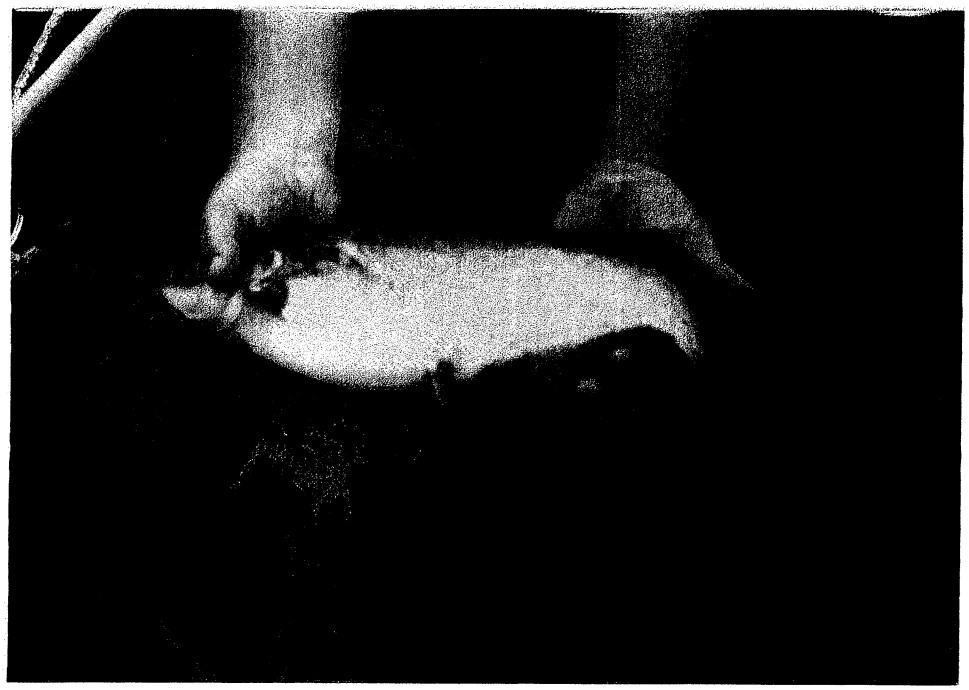
APPENDIX G

AQUATIC VOUCHER PHOTOGRAPHS

LIST OF PHOTOGRAPHS

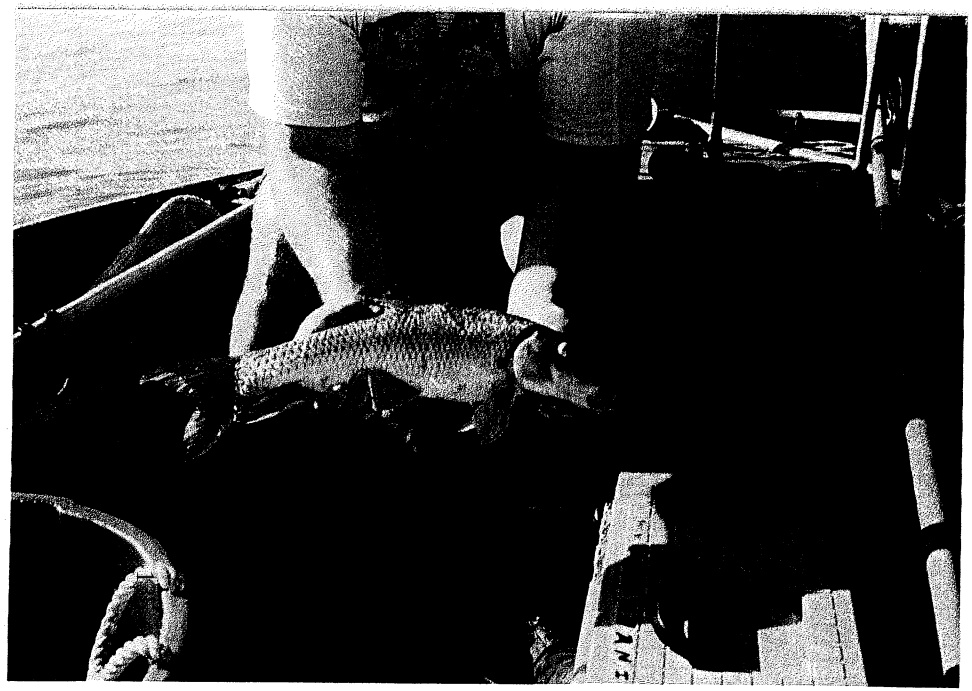
AQUATIC INVENTORY
GREENUP LOCKS AND DAM
VOUCHER PHOTOGRAPHS
MAY 1999

1	Channel Catfish
2	White/Striped Bass Hybrid
3	Golden Redhorse
4	Longnose Gar
5	Central Longear Sunfish
6	Pumpkinseed Sunfish
7	Northern Bluegill Sunfish
8	Freshwater Drum
9	Spotted Sucker
10	Skipjack Herring
11	Smallmouth Buffalofish
12	Highfin Carpsucker
13	Northern River Carpsucker
14	Black Redhorse
15	White Bass
16	Northern Largemouth Blackbass
17	Silver Chub
18	Common Emerald Shiners, Spotfin Shiners, Sand Shiners, River Shiners, Bluntnose Minnows, Spottail Shiners



1 - Channel Catfish

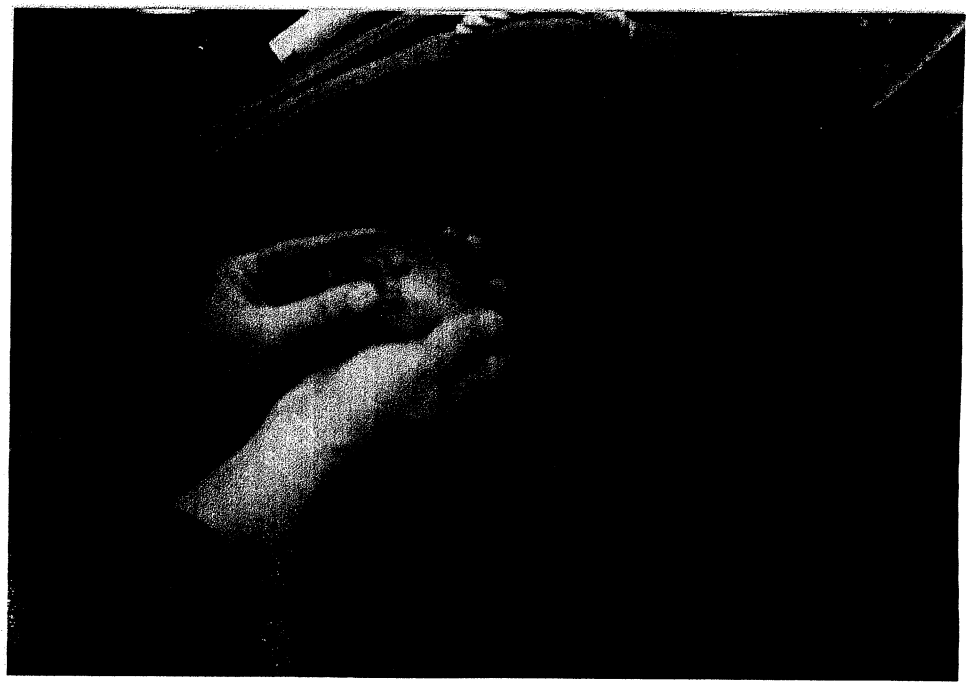
2 - White/Striped Bass Hybrid



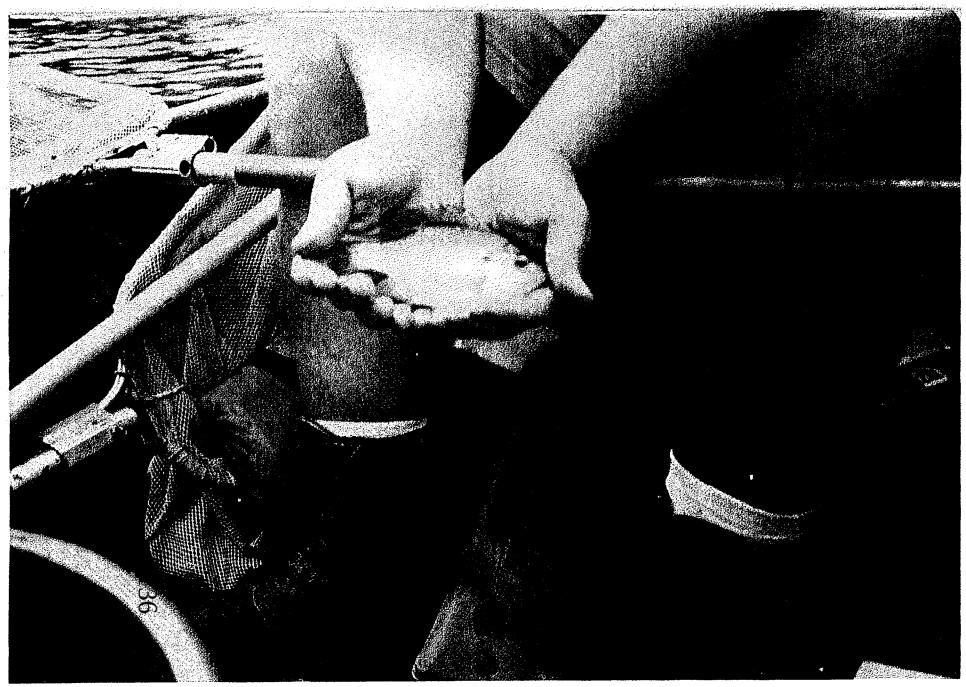
3 - Golden Redhorse

4 - Longnose Gar

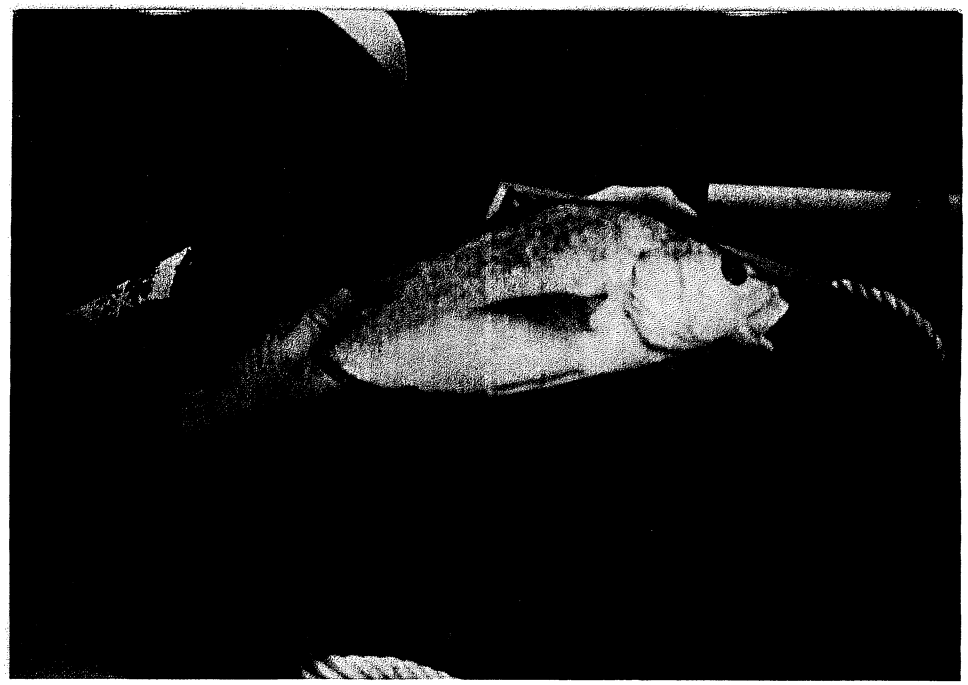
5 - Central Longear Sunfish



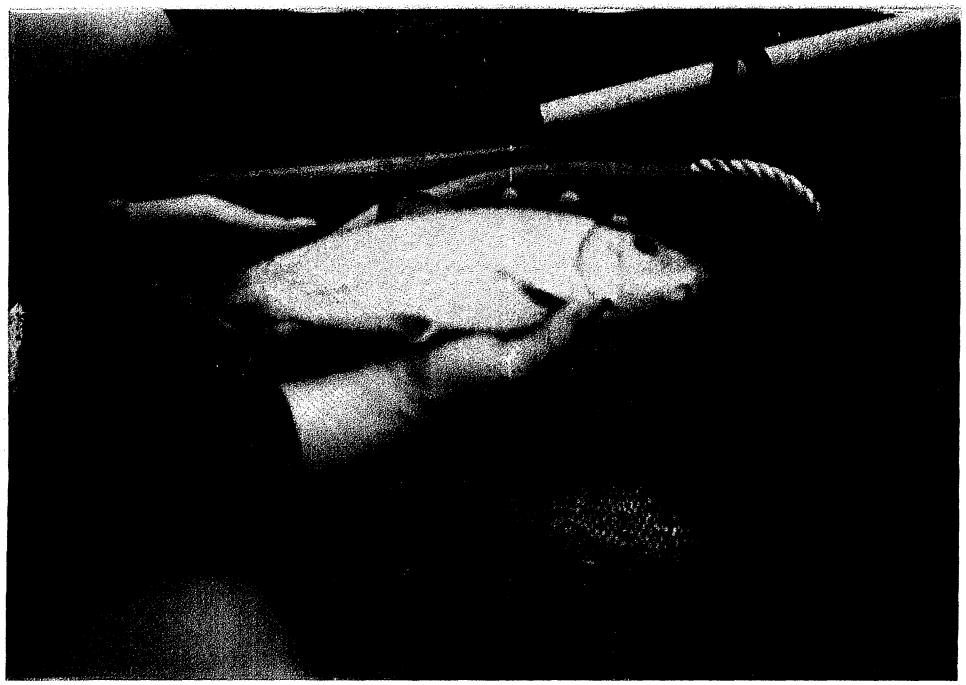
6 - Pumpkinseed Sunfish



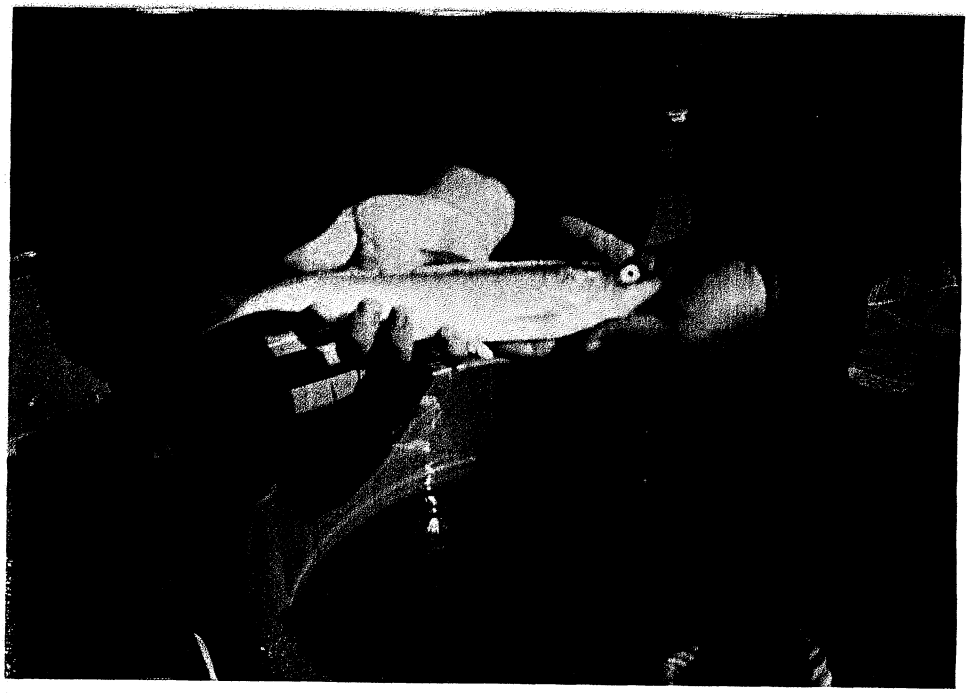
7 - Northern Bluegill Sunfish



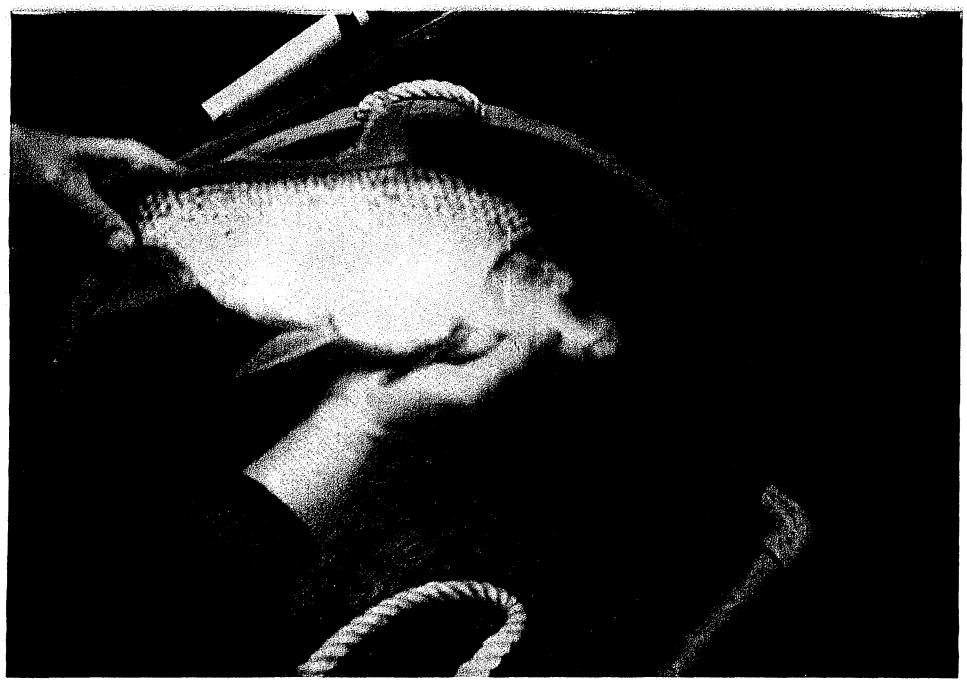
8 - Freshwater Drum



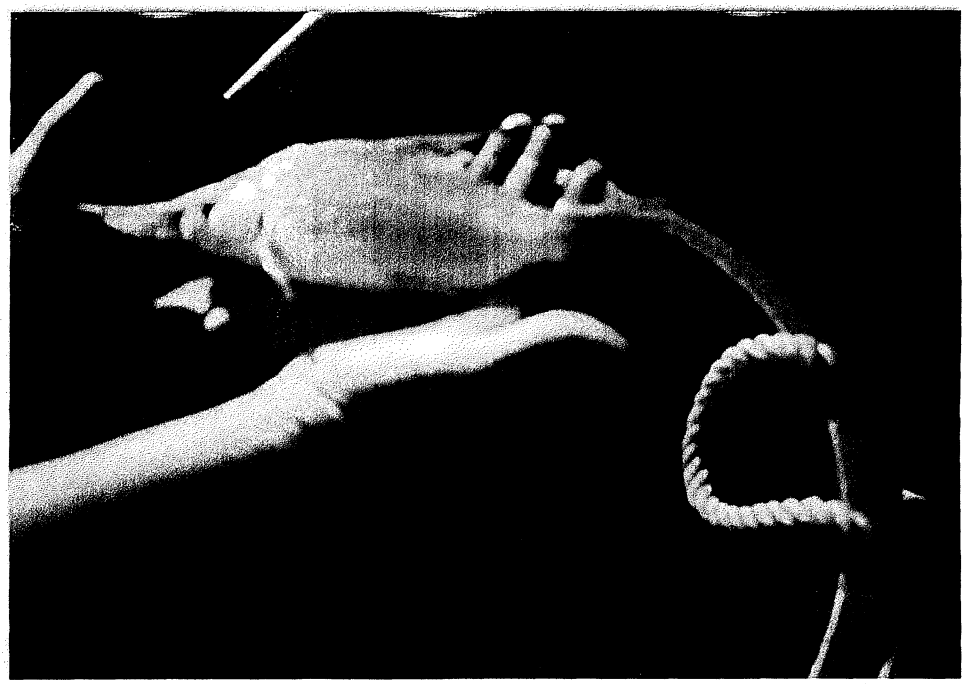
9 - Spotted Sucker



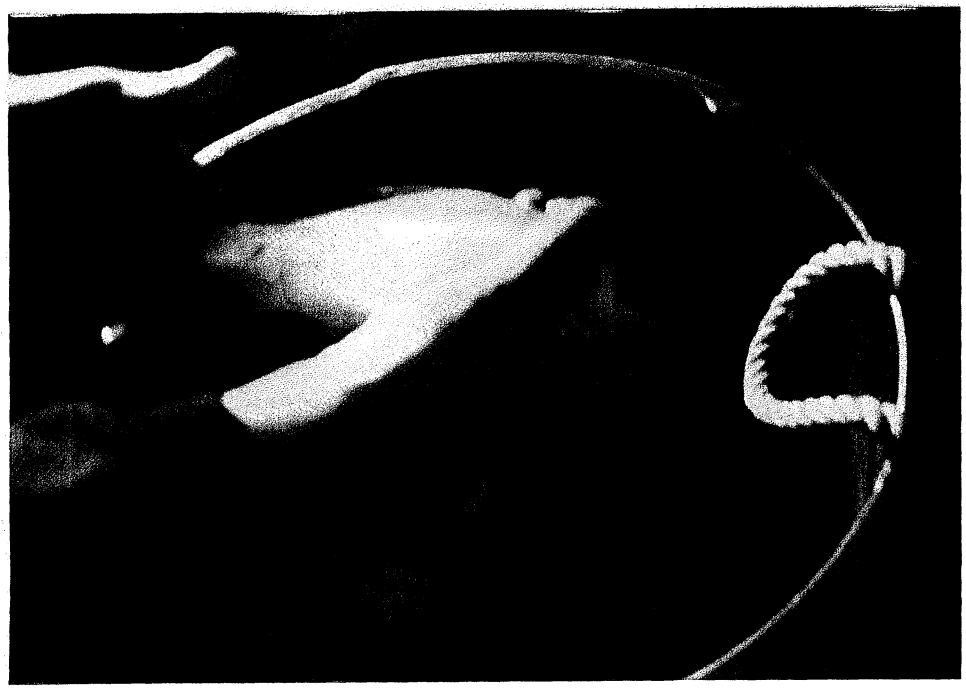
10 - Skipjack Herring



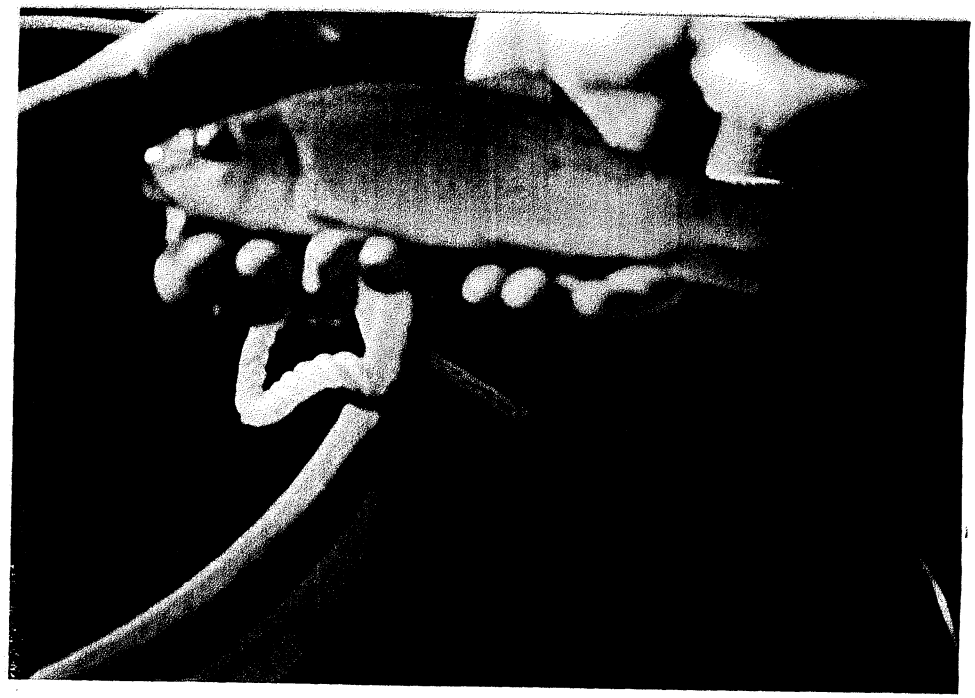
11 - Smallmouth Buffalofish



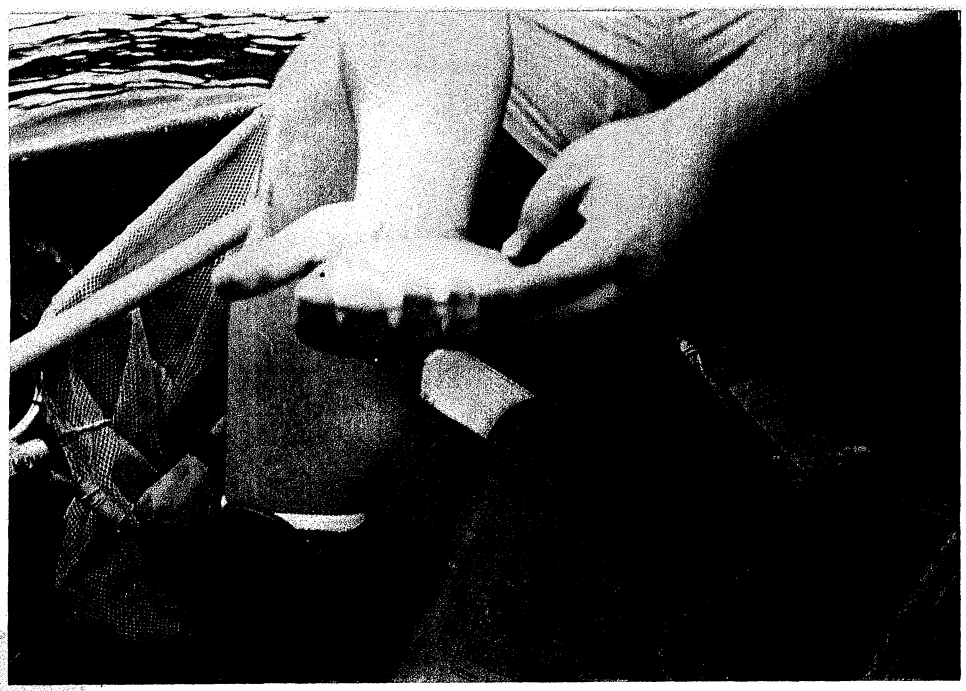
12 - Highfin Carpsucker



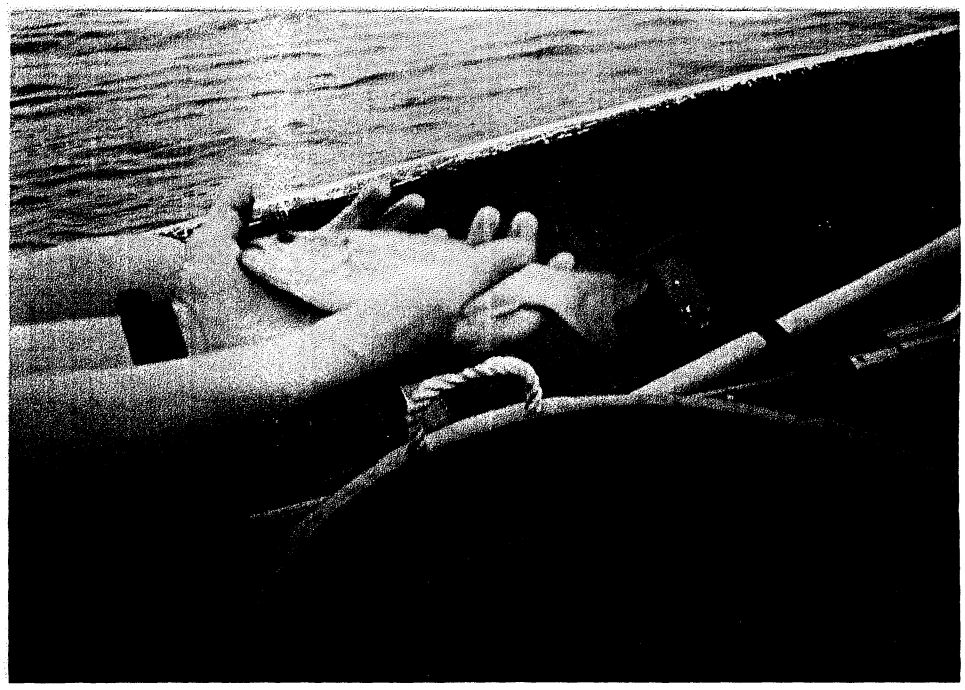
13 - Northern River Carpsucker



14 - Black Redhorse



Bass



16 - Northern Largemouth Blackbass

Part B-3.

Greenup Locks Improvements

Characterization of a *Unionid* Community near Greenup L&D

Characterization of a Unionid Community along the Ohio bank near the Greenup Locks and Dam: Ohio River Miles 340.5 to 343.0

Prepared for:
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Under Contract with:
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1.0 Introduction

The U.S. Army Corps of Engineers (USCOE) proposes extending the lock wall at Greenup Locks and Dam on the Ohio River. With the improving water and sediment quality in recent years (Cavanaugh and Mitsch, 1989; Pearson and Pearson, 1989; Youger and Mitsch, 1989), unionids have begun to flourish in many areas of the Ohio River. Recent studies have recorded 41 living and recently dead species in the upper river, 30 of which are present in Meldahl Pool (Table 1-1). These unionid communities are often diverse, and the Federally listed species *Cyprogenia stegaria* and *Lampsilis abrupta* have been found in several areas (ESI, 1996a, 1996b, 1998a, and 1998b; Miller and Payne, 1995; P. Morrison-USFWS, pers. comm.).

USCOE is concerned that unionids may be affected by construction activities during lock wall modification. Unionids could be affected by construction activities in several ways. Unionids living in the construction area could be crushed or dislodged during sheet piling placement and removal, and lock wall construction. Cofferdam dewatering and removal may result in substrate disturbance and downstream siltation. Construction activities (such as staging equipment near banks and in the water, barge spudding, etc.) may also crush or dislodge animals, or disturb substrate and streambanks, possibly resulting in downstream sediment deposition. Additionally, fish host activity in a unionid bed may be altered by habitat changes and/or altered flow patterns. These activities pose the greatest threat to unionids on the Kentucky bank. ESI (1999) conducted a survey to characterize the unionid community in this area, finding a diverse and reproducing population downstream of the Greenup Locks and Dam, but no live Federally endangered species.

Across the channel, the Ohio side of the river near the Greenup Locks and Dam is situated on the outside bank of a riverbend. Outside bends have more consistent flow, and are less depositional than inside bends (ESI, 1997). Such areas are often more conducive to unionid communities, and similar distribution patterns have been found on the Ohio River downstream of Belleville Locks and Dam (ESI, 1998a) and on the upper Connecticut River in Vermont/New Hampshire (Marangelo, 1997). The existence of a diverse unionid community on an inside bend (ESI, 1999) suggested that a community of even greater diversity and/or abundance might occur in potentially superior habitat on the outside bend. Williams and Schuster (1989) found nine unionid species while brailing between ORM 342.0 and 343.5 along the Ohio bank, even though their sampling method was fairly inefficient. Therefore, USCOE contracted Burgess & Niple and Ecological Specialists, Inc. to conduct additional surveys for unionids along the right descending bank of the Ohio River upstream and downstream of Greenup Locks and Dam. The objective of this study was to determine unionid species composition, relative abundance, and distribution within the study area.

Table 1-1. Recent unionid species records in the upper Ohio River.

Species[1]	Common Name	Status[2]	ORM 0 to 418.9[3,4]	Meldahl Pool [3,5]
Actinonaias ligamentina	mucket		L	L
Amblema p. plicata	threeridge		L	L
Cyclonaias tuberculata	purple wartyback		L	L
Cyprogenia stegaria	fanshell	FE,KYE,OE	L	
Ellipsaria lineolata	butterfly	OE	L	L
Elliptio crassidens	elephant-ear	OE	L	L
Elliptio dilatata	spike		L	L
Epioblasma t. torulosa	tubercled blossom	FE,KYE	SF	
Epioblasma triquetra	snuffbox	C2,KYS	FD	
Fusconaia ebena	ebonyshell		L	L
Fusconaia flava	Wabash pigtoe		L	L
Fusconaia subrotunda	long-solid	OE,KYT	L	
Lampsilis abrupta	pink mucket	FE,KYE,OE	L	
Lampsilis cardium	plain pocketbook		L	L
Lampsilis ovata	pocketbook	KYE,OE	L	L
Lampsilis siliquoidea	fatmucket		L	L
Lampsilis teres	yellow sandshell	OE	L	L
Lasmigona c. complanata	white heelsplitter		L	L
Lasmigona costata	fluted-shell		L	
Leptodea fragilis	fragile papershell		L	L
Ligumia recta	black sandshell		L	L
Megalonaias nervosa	washboard	OE	L	L
Obliquaria reflexa	threehorn wartyback		L	L
Obovaria olivaria	hickorynut	OE	SF	
Obovaria retusa	ring pink	FE,KYE	WD	SF
Obovaria subrotunda	round hickorynut		L	
Pleithobasus cicatricosus	white wartyback	FE	SF	
Plethobasus cooperianus	orange-foot pimpleback	FE,KYE,OE	WD	
Plethobasus cyphyus	sheepnose	KYS,OE	L	L
Pleurobema clava	clubshell	FE,KYE,OE	SF	
Pleurobema coccineum	round pigtoe		L	L
Pleurobema cordatum	Ohio pigtoe	OE	L	L
Pleurobema plenum	rough pigtoe	FE,KYE	SF	
Pleurobema pyramidatum	pyramid pigtoe	C2,KYE	SF	
Potamilus alatus	pink heelsplitter		L	L
Potamilus ohiensis	pink papershell		L	FD
Ptychobranchus fasciolaris	kidneyshell		SF	
Pyganodon grandis	giant floater		L	L
Quadrula metanevra	monkeyface	OE	L	L
Quadrula nodulata	wartyback	OE	L	L
Quadrula p. pustulosa	pimpleback		L	L
Quadrula quadrula	mapleleaf		L	L
Simpsonaias ambigua	salamander mussel	C2,KYT	FD	
Strophitus undulatus	squawfoot		L	
Toxolasma parvus	lilliput		L	
Tritogonia verrucosa	pistolgrip		L	L
Truncilla donaciformis	fawnsfoot		L	L
Truncilla truncata	deertoe		L	L
Utterbackia imbecillis	paper pondshell		L	
Uniomerus tetralasmus	pondhorn		L	
Total Species			50	31
Species Live (L and FD)			41	30
Species Weathered (WD and SF)			9	1

[1]Nomenclature follows Turgeon *et al.* (1988) and Hoeh (1990)

[2]FE=Federally Endangered (USFWS, 1996); C2=Former category 2 species (USFWS,1991); KYE=Kentucky Endangered, KYT=Kentucky Threatened, KYS=Kentucky Species of Special Concern (Kentucky State Nature Preserves Commission, 1994); OE=Ohio Endangered (ODNR, 1995)

[3]Best Condition; L=Live, FD=Freshly Dead Shell, WD=Weathered Shell, SF=Subfossil Shell

[4]Taylor (1980), Tolin and Schettig (1983), Zeto *et al.* (1987), ESE (1995), ESI (1990, 1991, 1993, 1994a, 1994b, 1995a, 1996a, 1996b, 1997, 1998a, 1998b, 1998c), Miller and Payne (1995), P. Morrison (pers. comm.), W. Tolin (pers. comm.)

[5]ESI (1998c), P. Morrison (pers. comm.)

2.0 Methods

Unionids were sampled in the Ohio River along the Ohio bank upstream and downstream of Greenup Locks and Dam (ORM 340.5 to 343.0) between August 9 -14, 1999. The main objective of this study was to determine if Federally endangered species would be affected by this project. The effort required to find uncommon species is often considerable, and they are rarely collected in brail or quantitative samples (Kovalak *et al.*; 1986, Strayer *et al.*, 1997). Timed searches yield a better estimate of unionid species richness than quantitative samples (Strayer *et al.*, 1997; Vaughn *et al.*, 1997), as well as providing relative abundance per unit of effort. Semi-quantitative sampling (timed visual and tactual searches within a given area) are less time consuming and generally yield a greater number of unionids than quantitative samples, while providing a relative idea of unionid distribution (Dunn, in press). Therefore, semi-quantitative sampling was used to estimate species composition and distribution of the unionid community. Additional qualitative timed searches were conducted in areas of unionid concentrations to increase the probability of finding rare or endangered species.

Semi-quantitative sampling was conducted along transect lines laid perpendicular to the right descending riverbank (Figure 2-1). Upstream of Greenup Locks and Dam, water depth exceeded safe diving limits (12m) beyond 50m of the riverbank. Therefore, transects were limited to 50m long, but were spaced 100m apart from ORM 340.5 to the lock wall (five transects). Downstream of Greenup Locks and Dam, 13 - 150m long transects spaced 200m apart were established perpendicular to the bank between the downstream end of the lock wall and ORM 343.0. No sampling was conducted within the restricted area of the dam (see Figure 2-1). Transects were marked at 10m intervals, and each 1m corridor within each interval (1 x 10m) was searched visually and tactually for four minutes and treated as a separate sample. General substrate composition was visually characterized by the diver in each interval and relayed to the surface crew.

To better characterize the unionid community, additional qualitative sampling was conducted in areas of unionid concentrations (between Transects 9 – 10 and 17 –18) until 1000 or more live unionids were collected. Additionally, the entire shoreline from Transect 11 to 18 was searched for shells.

All live unionids were identified, measured (length in mm), aged (external annuli count), and weighed (grams). Empty shells were also collected, identified, and categorized as freshly dead (nacre still lustrous, probably died within the last year), weathered (nacre chalky, probably dead more than a few years), or subfossil (periostracum eroded or shell fragmented, probably dead >10 years).

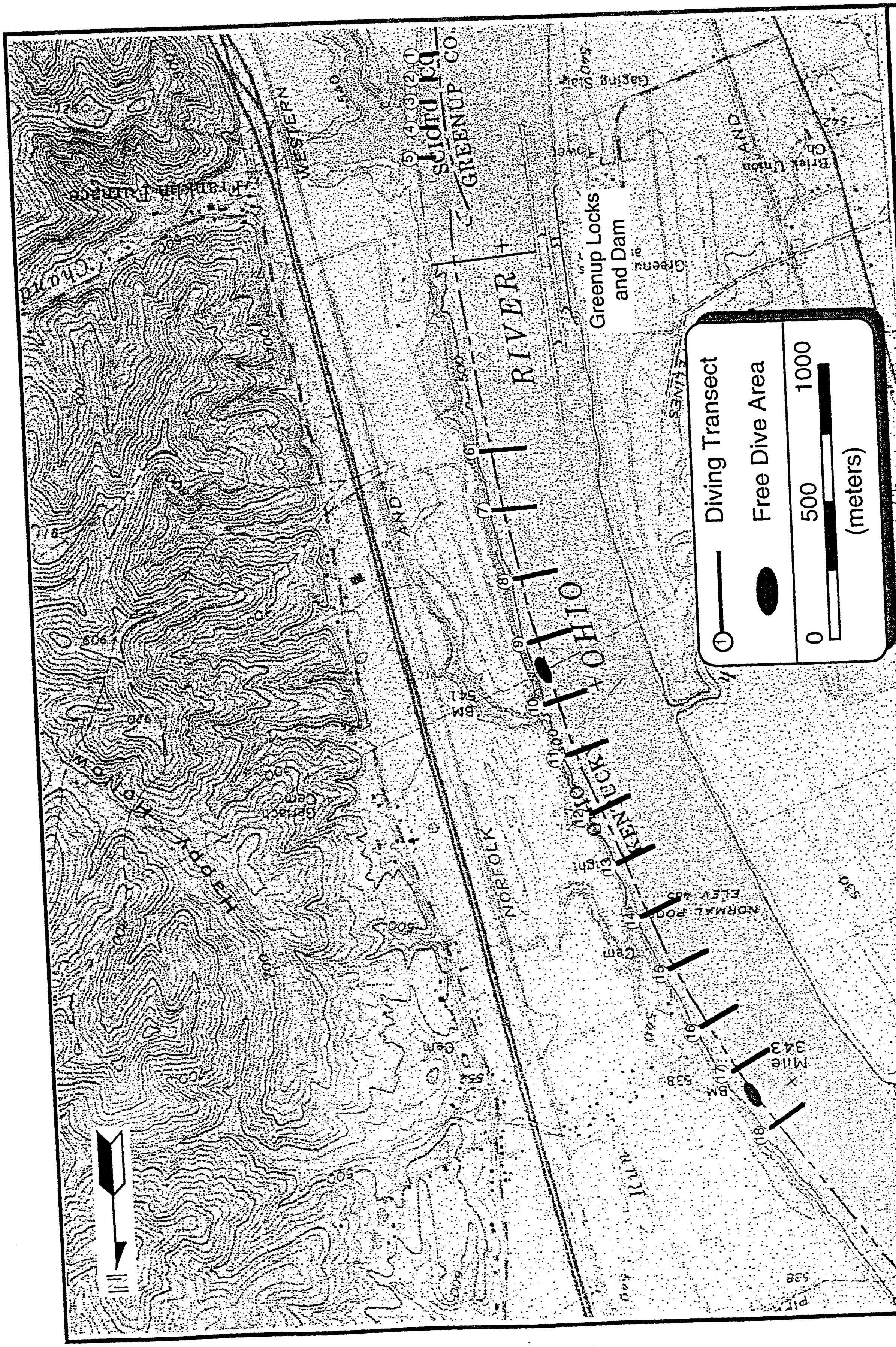

Figure 2-1. Diving locations near Greenup Locks and Dam (ORM 340.5 to 343.0), Ohio bank, August 1999.

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3.0 Results and Discussion

3.1 Habitat Characteristics and Sampling Conditions

Habitat differed considerably upstream and downstream of the dam. Upstream, current velocity was <0.1 knots, and water depth averaged 7.1m within 50m of the bank, but was >12m at 50m. Substrate consisted primarily of fine depositional sediment mixed with small amounts of gravel (Table 3-1).

Downstream of the lock, water was shallower, averaging 3.7m (range 2 to 4.6m) within 50m of the bank, and 4.2 m (range 2.0 to 5.2m) between the bank and 150m. Current velocity was generally a function of distance from the hydropower outlet in the Greenup Dam on the Ohio bank. Current velocity ranged from <0.01 knots at transects farthest from the hydropower outlet to 1.7 knots at Transect 6, and varied in time in accordance with dam releases. Substrate generally was coarser downstream of the dam than upstream due to increased flow. Also, substrate characteristics varied with downstream distance from the dam and distance from the bank. Substrate was more heterogeneous within 50m of the bank, and contained finer sediment, particularly downstream of Transect 14, where influence of dam releases was minimal. Between 50 to 100m, substrate was primarily cobble, gravel, and sand. Beyond 100m substrate was mainly bedrock, boulder, and large cobble.

3.2 Unionid Fauna

A diverse and reproducing unionid bed exists within portions of the study area, but no Federally protected species were found. Overall, the study area yielded 16 live species and weathered dead shells of an additional four species (Table 3-2). Semi-quantitative sampling revealed distinct distribution patterns. Upstream of the dam, few live individuals or shells were collected along Transects 1 to 5 (Tables 3-3 and 3-4). This is likely due to the fine sediment and lack of flow associated with impoundment (Bates, 1962; Suloway *et al.*, 1981; ESI, 1995b). Downstream of the dam, most unionids were collected within 50m of the bank (see Table 3-3). Of the 197 live unionids of 13 species collected in semi-quantitative samples, 160 (81%) were found in this area. Also, CPUE averaged 6.95/10 minutes of search time, and density averaged 0.24/m^2 (see Table 3-3). Unionids were scarce along Transects 6 and 7, and most abundant along Transects 9 – 11, where 116 specimens (58% of total collected) were collected within 50m of the bank. Here CPUE averaged 19.3 unionids/10 min. and density averaged 0.77/m^2 (see Table 3-3). Transects 12 – 18 yielded moderate numbers of live unionids. Riverward of 50 m, substrate appeared unstable (gravel and sand) or consisted of less hospitable bedrock, boulder, and cobble (see Table 3-1), and only a few scattered individuals were found (see Table 3-3).

An additional 952 live unionids were collected during qualitative searches within 50m of the bank between Transects 9 - 10 and 17 – 18. This effort yielded live specimens of two species not found during the transect sampling (*Lampsilis ovata* and *Quadrula quadrula*).

Table 3-1. Habitat characteristics along transects on the Ohio River near Greenup Locks and Dam, (ORM 340.5 to 343.0), August 1999.

Transect no.	Distance from bank(m) 0-50 Ave. depth(m)	0-50 Substrate[1]	50-100 Ave. depth(m)	50-100 Substrate[1]	100-150 Ave. depth(m)	100-150 Substrate[1]	Temp. (C°)	Dissolved Oxygen (ppm)	Secchi (mm)
1	7.13	Gr/Sd/St					29	6.5	>2000
2	6.86	Gr/St/detritus					29	6.5	>2000
3	6.77	Gr/St/detritus					29	6.5	>2000
4	7.44	Sd/St/detritus					29	6.5	>2000
5	7.32	Gr/Sd/St					29	6.5	>2000
6	4.33	Br/Bd/Cb/Gr	3.66	Bd/Cb/Gr	2.87	Cb/Gr	29	6.9	>2000
7	3.66	Cb/St	4.88	Bd	5.06	Bd	29	6.9	>2000
8	3.35	Br/Bd/Cb/Gr/Sd/St	5.12	Br/Bd	4.38	Cb/Gr/Sd	29	6.4	>2000
9	4.18	Bd/Cb/Gr/Sd/St	5.18	Br/Cb/Gr	4.57	Br/Bd/Cb/Gr	29	6.4	>2000
10	4.29	Bd/Cb/Gr	4.88	Br/Bd/Cb/Gr	4.88	Br/Bd/Cb/Gr/Sd	29	6.4	>2000
11	4.65	Bd/Cb/Gr/Sd	4.57	Bd/Cb/Gr	5.12	Bd/Cb/Gr/Sd	29	6.4	>2000
12	4.05	Cb/Gr/St	4.06	Bd/Gr/Sd	4.45	Bd/Gr	29	6.4	>2000
13	4.08	Cb/Gr/Sd/St	4.45	Br/Cb/Gr	4.63	Br/Cb/Gr	29	6.4	>2000
14	3.77	Cb/Gr/Sd	4.57	Br/Bd/Gr/Sd	4.64	Br/Bd/Gr/Sd	27	6.6	>2000
15	1.97	Gr/Sd	4.57	Cb/Gr/Sd	4.57	Bd/Cb/Gr/Sd	27	6.6	>2000
16	3.54	Bd/Gb/Gr/Sd	4.27	Gr/Sd	4.27	Bd/Cb/Gr/Sd	27	6.6	>2000
17	3.54	Gr/Sd	4.27	Gr/Sd	4.57	Cb/Gr/Sd	27	6.6	>2000
18	3.11	Gr/Sd	3.61	Br/Bd/Gr/Sd	4.61		27	6.6	>2000
Total	4.35		4.43		4.51				

[1]Br = bedrock, Bd = boulder, Cb = cobble, Gr = gravel, Sd = sand, St = silt

Table 3-2. Unionid relative abundance and community characteristics near Greenup Locks and Dam, (ORM 340.5 to 343.0), August, 1999.

Species	No.	%	Age (years)			Length (mm)			Weight (g)		
			Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Actinonaias ligamentina	2	>1	10.0	5	15	94.0	75	113	121.5	85	158
Amblema p. plicata	147	13	8.5	3	28	74.1	27	133	137.6	10	512
Ellipsaria lineolata (OE)	62	5	5.7	3	10	59.5	38	80	66.7	15	158
Elliptio crassidens (OE)	9	1	18.9	14	25	105.4	95	121	278.6	240	360
Fusconaia ebena	2	>1	15.5	6	25	65.0	42	88	195.0	40	350
Fusconaia flava	2	>1	6.5	6	7	60.0	57	63	46.0	46	46
Fusconaia subrotunda (OE, KYT)	WD	0									
Lampsilis cardium	36	3	8.9	4	17	108.2	85	132	293.0	125	505
Lampsilis ovata (OE, KYE)	1	>1	6.0	6	6	106.0	106	106	258.0	258	258
Lampsilis siliquoidea	3	>1	10.7	5	16	99.0	78	118	214.7	100	402
Leptodea fragilis	1	>1	3.0	3	3	40.0	40	40	4.0	4	4
Ligumia recta	25	2	6.2	3	12	115.2	16	146	160.8	49	317
Megalonaias nervosa (OE)	WD	0									
Obliquaria reflexa	617	54	5.5	2	13	43.6	24	116	35.4	4	170
Pleurobema coccineum	WD	0									
Pleurobema cordatum (OE)	WD	0									
Potamilus alatus	24	2	5.7	4	8	93.0	43	118	84.6	32	130
Quadrula metanevra (OE)	24	2	7.5	3	15	59.5	28	81	84.4	8	190
Quadrula p. pustulosa	181	16	7.2	2	14	44.7	21	76	49.4	5	130
Quadrula quadrula	13	1	9.8	5	13	61.4	39	71	82.3	25	118
Total	1149		6.5	2	28	54.5	16	146	69.1	4	512
Total ≤ 5 yeas of age	507										
Total ≤ 3 years of age	57										

OE = Ohio endangered, KYE = Kentucky endangered, KYT = Kentucky threatened

Some of the variation in abundance downstream of the dam within 50m of the bank can be explained by the hydrology associated with dam releases from the hydropower turbines near the Ohio bank. The relative lack of unionids downstream of the lock and dam area along Transects 6 and 7 is probably due to effects of dam releases on substrate characteristics. During low flow, most of the discharge from the dam is through the hydropower turbines located near the Ohio bank. Flow out of the turbines appears to be directed at an angle toward the Kentucky bank, and turbulent conditions predominate on the Ohio bank downstream until about Transect 7. This flow pattern probably scours out the areas around Transects 6 - 7, thus creating unstable/hard substrate conditions unfavorable for unionids. This is consistent with the trend in particle sizes, which generally appear to decrease from upstream to downstream inside of 50m from the bank (see Table 3-1).

Unionid distribution patterns in the study area are hardly surprising, given that unionids are usually more abundant near the bank in large rivers than in the river channel (Way *et al.*, 1989; Miller and Payne, 1993; ESI, 1994c). Additionally, unionid beds are usually found in areas of stable sand, gravel, and cobble substrate, which is typically indicative of suitable unionid habitat (Strayer and Ralley, 1991; Vaughn, 1997). The greater amount of sedimentary material near the bank, and a preponderance of bedrock near the channel, suggests that substrate is more suitable for unionids near the bank, except for the areas affected by dam releases.

Although no live Federally listed species were collected, a subfossil shell of the Federally endangered *Obovaria retusa* was collected during the survey of the Kentucky bank (ESI, 1999). Four live species listed as endangered in Ohio or Kentucky were collected during this survey (*Ellipsaria lineolata, Elliptio crassidens, Quadrula metanerva,* and *Lampsilis ovata*). Weathered dead shells of Kentucky/Ohio protected *Megalonaias nervosa*, *Pleurobema cordatum*, and *Fusconaia subrotunda* were also collected. *Obliquaria reflexa* (54%), *Quadrula p. pustulosa* (16%), and *Amblema p. plicata* (13%) dominated the community (Table 3-2). *Ellipsaria lineolata* (5%), *Lampsilis cardium* (3%), *Ligumia recta* (2%), *Potamilus alatus* (2%) *Quadrula metanerva* (2%) were also relatively common, while the remaining species comprised 1% or less of the community. One species collected in this study is relatively uncommon in the upper Ohio River (*L. ovata)*. Conversely, *Lasmigona c. complanata,* a species usually found in the upper Ohio River, was absent in this study.

Young animals (≤5 years old; 44% of all live individuals) and juveniles (≤3 years old; 5% of all live individuals) were fairly common in the study area, whereas older animals were scarce (Figure 3-1). This demographic pattern appears to be indicative of a developing unionid bed. The methods used in this study (semi-quantitative and qualitative) are typically biased toward larger animals, and juveniles are generally under represented in samples (Payne *et al.*, 1997; Vaughn *et al.*, 1997). Therefore it is

remarkable that juvenile unionids were so common, indicating that successful recruitment is occurring for at least 11 species. Conversely, older unionids (>15 years) were fairly scarce (see Figure 3-1). Thus the age of all sampled animals averaged only 6.1 years (see Table 3-2). Similar age distribution occurs in a unionid bed downstream of the Belleville Locks and Dam, and density has steadily increased in that bed over the past five years (ESI, 1998a).

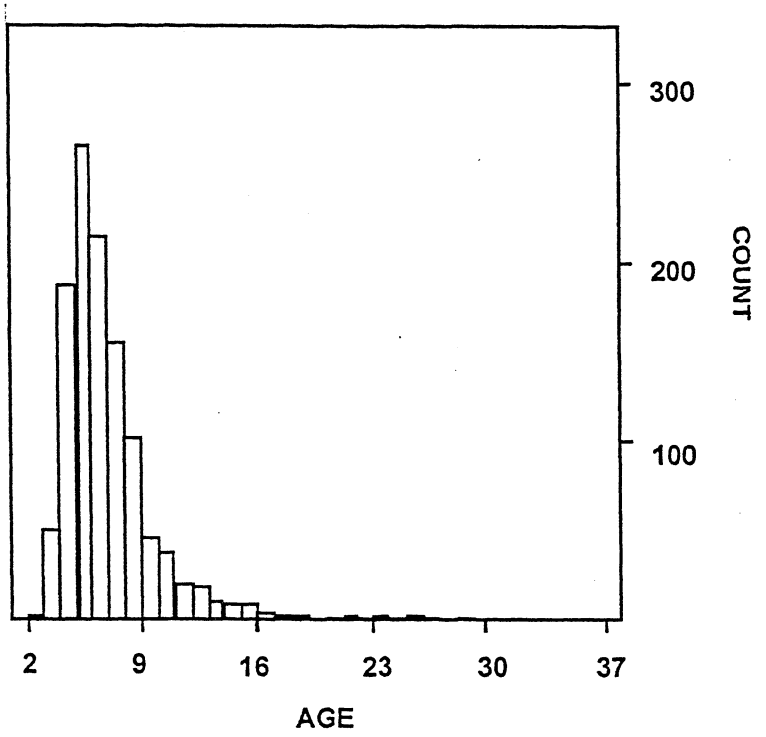
Table 3-3. Distribution of live unionids between ORM 340.5 to 343.0 on the Ohio bank. Average density of the shaded area is 0.77/m^2. Average density of all areas sampled is 0.09/m^2.

Dist. from bank (m)	Transect 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total	Ave. den. 1 - 5	Ave. den. 5 - 18
0-10	0	0	0	0	0	1	1	4	0	7	1	0	0	0	0	2	0	0	16		
10-20	0	1	0	0	0	1	0	5	0	16	8	0	0	1	0	0	0	0	32		
20-30	1	0	1	0	0	0	0	0	6	21	13	1	1	1	1	0	0	0	46	0.03	0.24
30-40	1	1	0	0	1	1	0	0	14	4	10	2	0	2	4	0	1	1	42		
40-50	1	0	0	0	0	1	0	0	15	0	1	0	0	3	0	3	0	0	24		
50-60						0	0	0	0	0	1	0	1	2	1	1	6	0	13		
60-70						0	0	0	0	0	0	1	0	0	2	0	0	2	6		
70-80						0	0	0	0	0	0	0	0	0	0	2	1	0	3		
80-90						0	0	0	0	2	0	0	0	0	0	0	0	0	2		
90-100						0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	0.03
100-110						0	0	6	0	0	0	0	0	1	0	0	2	0	9		
110-120						0	0	2	0	1	0	0	0	0	0	0	0	0	3		
120-130						0	0	0	0	0	0	0	0	0	0	0	0	0	0		
130-140						0	0	0	0	0	0	0	0	0	0	0	0	2	2		
140-150						0	0	0	0	1	0	0	0	0	0	0	0	0	1		
Total	3	2	1	0	1	4	1	17	35	52	34	4	2	10	10	7	9	5	197		

Table 3-4. Comparison of unionid abundance and species composition along all transects.

Species	Transect 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Actinonaias ligamentina															WD	WD	1		1
Amblema p. plicata	2	2			1		1	11	10	3	5	2		1	1				39
Ellipsaria lineolata (OE)									2	1			1						4
Elliptio crassidens (OE)														WD	3	1	2	1	7
Fusconaia ebena																WD	1		1
Fusconaia flava											1								1
Fusconaia subrotunda (OE,KYT)															WD				WD
Lampsilis cardium						2		3		3	1	1		1	1		1		13
Lampsilis siliquoidea									1			WD							1
Leptodea fragilis															WD				WD
Ligumia recta						1			1	2	2			2		1	1	1	11
Megalonaias nervosa (OE)														WD					WD
Obliquaria reflexa	1		1					2	15	31	20	1	1	3	2	4		1	82
Pleurobema coccineum														WD					WD
Pleurobema cordatum (OE)															WD	WD			WD
Potamilus alatus		WD	WD	WD		1		1	2	2	1	WD		1		WD			8
Quadrula metanevra (OE)										3	1			1	2	1	1		9
Quadrula p. pustulosa									4	7	3			1	1	WD	2	2	20
Quadrula quadrula		FD												WD	WD	WD			FD
Total	3	2	1	0	1	4	1	17	35	52	34	4	2	10	10	7	9	5	197
No. Live Species	2	1	1	0	1	3	1	4	7	8	8	3	2	7	6	4	7	4	13
Total Species	2	3	2	1	1	3	1	4	7	8	8	5	2	11	11	10	7	4	19
CPUE (No./10min.)	1.50	1.00	0.50	0.00	0.50	0.67	0.17	2.83	5.83	8.67	5.67	0.67	0.33	1.67	1.67	1.17	1.50	0.83	
Density (No./m^2)[1]	0.06	0.04	0.02	0.00	0.02	0.03	0.01	0.11	0.23	0.35	0.23	0.03	0.01	0.07	0.07	0.05	0.06	0.03	

[1]Approximate density based on 5 1x10m qualitative samples along Transects 1 – 5 and 15 1x10 qualitative samples per transect along Transects 6 -18.
FD = freshly dead, WD = weathered dead
OE = Ohio endangered, KYT = Kentucky threatened



ECOLOGICAL SPECIALISTS.	Figure 3-1. Age distribution of all unionids found along the Ohio bank, ORM 340.5 to 343.0, August 1999.	ESI

4.0 Conclusions and Recommendations

Unionids appear to be located primarily in suitable substrate areas downstream of the Greenup Locks and Dam, primarily within 50m of the bank and between Transects 9 – 11. The large proportion of juveniles in the population suggests that the unionid community is generally healthy and demographically vigorous. Although density appears to be low, species richness was relatively high (16 species), and recent recruitment is apparent. No Federally endangered species were collected. However, Federally endangered species have been collected in other upper Ohio River beds (ESI, 1998a) with similar characteristics (low density, high species richness, and evidence of reproduction), and several species that are rare in the upper Ohio River and/or are protected by Kentucky and/or Ohio were found. Thus it is possible that Federally endangered species may be present, but extremely rare (<0.01% of the community).

This concentration of unionids along the Ohio bank will probably not be affected by this project since it is located at least 1500m downstream of the dam and is on the /other side of the river from the lock. However, this bed should be considered in project planning.

Given that the opposite bank (situated on the inside of a riverbend) supports a more diverse community of unionids (18 species; ESI 1999), it was somewhat surprising that the present study found fewer individuals and fewer species along the outside bed, which is typically superior habitat. However, flow is diverted toward the Kentucky bank by the hydropower facility, scouring the substrate immediately downstream of the dam, and supplying flowing water to an otherwise depositional area on the Kentucky bank. Nevertheless, the Ohio bank of the Ohio River appears to support a reproducing unionid bed, and young animals were a much larger proportion of the population than along the Kentucky bank (44% vs. 8%). If zebra mussels do not severely impact unionids in the study area, it could potentially develop into a diverse high density bed.

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